ENCYCLOPEDIA OF

INFORMATION COMMUNICATION TECHNOLOGY

Volume I

Antonio Cartelli & Marco Palma

CARTELLI & PALMA

Encyclopedia of Information Communication Technology

Volume II

Information Science REFERENCE

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Information Science REFERENCE

INFORMATION SCIENCE REFERENCE
Hershey · New York

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Printed at:	Yurchak Printing Inc.

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue, Suite 200
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com/reference

and in the United Kingdom by
Information Science Reference (an imprint of IGI Global)
3 Henrietta Street
Covent Garden
London WC2E 8LU
Tel: 44 20 7240 0856
Fax: 44 20 7379 0609
Web site: http://www.eurospanbookstore.com

Library of Congress Cataloging-in-Publication Data

Encyclopedia of information communication technology / Antonio Cartelli and Marco Palma, Editors.
p. cm.
Summary: "This book is a comprehensive resource describing the influence of information communication technology in scientific knowledge construction and spreading, with emphasis on the roles of product technologies, process technologies, and context technologies"--Provided by publisher.
ISBN-13: 978-1-59904-845-1 (hardcover)
ISBN-13: 978-1-59904-846-8 (e-book)
1. Telecommunication--Encyclopedias. I. Cartelli, Antonio, 1954- II. Palma, Marco.
TK5102.E644 2008
004.6'5--dc22
2007043957

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Editorial Advisory Board

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Preface

The information and communication technology revolution can be easily recognized as the latest revolution in the history of mankind, impacting every facet of business, society, and life worldwide with a speed beyond imagination. The last centuries have seen a continuous evolution process, which started with the industrial revolution at the end of 18^{th} century. This revolution has its roots in the invention of the first electronic computers in the 1940s, continued with the development of information technology during the following decades and exploded in the early 1990s. In the 1960s and 1970s, computer technology was mainly utilized in business data processing and scientific applications of a mostly number crunching nature. As a result, the use of this technology was limited to those who had a good command of these systems and computer programming languages. With the invention of microprocessors a new idea of distributed information established itself and computers became available on a personal basis. The contemporary development of networking both on a local and a wide area (LAN and WAN) merged computer and information technology with telecommunication. In the 1980's the matching of the two technologies led to the information communication technology, with a strong focus on the management and dissemination of information by both providers and users.

The most noticeable explosion in the information and communication technology revolution was the creation of the World Wide Web (WWW) and its potential in the early 1990s. During the past two decades, WWW technologies have become the driving force in allowing people worldwide to communicate and exchange information in ways that have created a totally new dimension for mankind, at such a point that "global villages" are the words today better describing our planet. In recent years, through the use of Web-enabled technologies, organizations of all types and sizes around the world have managed to utilize these technologies to conduct both information processing and dissemination with their prospective customers, suppliers, students, and governments. These technologies, now allowing readily available information for everyone regardless of their geographic location, bring the true meaning of the information age to its full realization and prepare a new era for mankind: the knowledge society.

In recent years, the science of understanding the nature of information processing and management combined with computer and telecommunication technologies to process, disseminate, and manage information has become known as "information and communication science and technology." It has many resources and components and originated many new disciplines but, what's more, it intervened in changing mankind's habits and lifestyle.

As information and communication science and technology have profoundly impacted science, business, society, and every other aspect of life on our planet, numerous researchers around the world have focused on accumulating knowledge on this discipline and its effects and influences. The volume and intensity of research in the field of information and communication science and technology and the study of its implications on human and social behavior has by far exceeded many other fields of science, and the sheer impact of research discoveries in this area has become the driving force of many emerging studies, technologies, and applications. No longer is this discipline limited to a few technology-related areas, but as for many other modern fields of knowledge, information, and communication science and technology are today a collection of a great variety of specific disciplines. This collection process has been accomplished by producing research results to understand the potentials, problems, and challenges of each individual discipline, analyzing the cross-fertilization on neighboring fields of knowledge and trying to expand the body of literature related to the topics of that discipline. As a result we can today use the words of D. de Kerchkove (1995) who stated that a technology enters human culture when it disappears or, to be more precise, when it becomes transparent.

To access the latest research related to the many disciplines of the information and communication science and technology field, we decided to launch an encyclopedia project where researchers from all over the world would assist us in providing the necessary coverage of each respective discipline in information and communication science and technology and in the fields affected from its influence and application. The primary objective of this project was to assemble research coverage related to the disciplines selected for this encyclopedia by defining the technologies, terms, and acronyms related to each discipline, and providing the most comprehensive list of research references related to each discipline.

To provide the most comprehensive, in-depth, and recent coverage of the developments of information and communication science and technology and its application and influence, three different areas of interest were selected:

- Product ICT, focusing on materials, instruments for ICT, that is, hardware and software for information communication, including studies, hypotheses, case studies, and so forth.
- Process ICT, focusing on processes including ICT use or presence, that is, the organization and management of processes in different environments by means of ICT (where it is used), and the planning and carrying out of experiences and projects for information and communication management and/or involving ICT use.
- Context ICT, focusing on the most pervasive presence of ICT, that is, experiences, studies and researches on information and communication technologies in informal and/or not well structured contexts, otherwise said the influence of ICT on human and social phenomena (when there is no planned and structured ICT intervention but the changes inducted by ICT clearly emerge).

In order to provide the best-balanced coverage of concepts and issues related to the selected topics of this encyclopedia, researchers from around the world were asked to submit proposals describing their experiences and the contribution of their work to the encyclopedia. All proposals were carefully reviewed by the editors-in-chief in light of their suitability, the authors' records of similar work in the area of the proposed topics, and the excellence of their proposals. The goal was to assemble the best minds in the information and communication science and technology field and their use and application from all over the world to contribute entries to the encyclopedia. Each text was forwarded to at least three expert external reviewers on a double blind, peer review basis. Only submissions with strong and favorable reviews were chosen as entries for this encyclopedia.

As a result, this encyclopedia includes more than 100 entries highlighting current concepts, issues and emerging technologies, studies, and applications. All entries are written by distinguished scholars from many prominent research institutions all over the world. Thousands of technical and managerial terms enhance these entries. Each of these terms has a description that allows the readers of this extensive research source to learn the language and terminology of the field. In addition, this encyclopedia offers a thorough reference section with sources of additional information for scholars, students, and researchers in the field of information science and technology.

To assist readers in navigating and identifying needed information, this encyclopedia has been organized by listing all entries in an introductory chapter to each section.

In addition, a comprehensive glossary of all terms directs readers to a short definition of the subject. A keyword index is also available, listing the most important concepts.

To keep up with emerging technologies and research discoveries, regular entry additions will be made to the online version of the encyclopedia. We are pleased to add that complimentary online access to this encyclopedia for the life of the edition will be provided to any library with the purchase of the print copy. This complimentary online availability will allow students, researchers, and corporate managers to access the latest contents of this comprehensive and in-depth encyclopedia regardless of their location. This particular feature will prove to be an extremely valuable resource for distance learning educational programs worldwide.

The diverse and comprehensive coverage of multiple disciplines in the field of information and communication of science and technology in this authoritative encyclopedia will contribute to a better understanding of all topics, researches, and discoveries in this evolving, significant field of study. Furthermore, the contributions included in this encyclopedia will be instrumental in the expansion of the body of knowledge in this vast field. The coverage of this encyclopedia provides strength to this reference resource for both information and communication science and technology researchers and also decision makers in obtaining a greater understanding of the concepts, issues, problems, trends, challenges, and opportunities related to this field of study. It is our sincere hope that this publication and its vast amount of information and research will assist our colleagues, their students, and our organizational decision makers in enhancing their understanding of this discipline and its application. Perhaps this publication will even inspire its readers to contribute to the current discoveries in this immense field, which can assist the mankind in making the world a better place to live in.

Antonio Cartelli and Marco Palma
(Editors)

de Kerchkove, D. (1995). *The skin of culture*. Toronto: Somerville House.

Acknowledgment

The editors would like to acknowledge the help of all persons involved in the collation and review process of the encyclopedia, without whose support the project could not have been completed. A further special note of thanks goes also to all the staff at IGI Global, whose contributions throughout the enire process from the initial idea to the final publication have been invaluable.

Most authors of the articles included in this encyclopedia also served as referees for articles written by other authors. Thanks go to all those who provided constructive and comprehensive reviews. However, some of the reviewers must be mentioned as their reviews set the benchmark. Reviewers who provided the most comprehensive, critical and constructive comments include: Marco Pedroni, Giorgio Poletti, Athanassios Jimoyannis, Terry T. Kidd, and Lawrence Tomei. We thank them in a particular way for their outstanding contribution.

Special thanks also go to Jan Travers, who kept the project on schedule, and Kristin Roth, whose enthusiasm motivated us to accept the initial invitation to take on this project and supported us in carrying it out.

Finally, we wish to thank all authors for their insights and excellent contributions to this encyclopedia. We also want to thank all people who assisted us in the reviewing process. Last but not least, we wish to thank our relatives and friends for their patience and support throughout the realization of this project.

Antonio Cartelli and Marco Palma (Editors)
March 2008

About the Editors

Antonio Cartelli was born in Cassino (Italy) in 1954. He graduated in mathematics at "La Sapienza" University in Rome and obtained, in the same university, the after-degree Special School Diploma in physics. After the degree he taught nonstop until 2001-2002 school year in national schools of different level.

Outside the school he had different professional experiences. He was teacher of computer science in the educational center of the local medical structure and in in-service training courses for teachers, he was also tutor for programming languages and networking in distance courses, system administrator and Webmaster in an Internet service provider and network administrator, Webmaster and networking consultant for the Faculty of Humanities in the University of Cassino.

As a winner of the national competition for a researcher he is now in the employ of the Faculty of Humanities of the University of Cassino, Italy, where he teaches basic computer science and teaching and learning technologies.

He actively participated in many national and international research activities and in 2006 coordinated the research local unit of the University of Cassino in a national project directed from the University of Florence and in an international projects coordinated from the University of Paisley, Scotland, UK.

He actually manages:

a. The Faculty Centre for ICT and on line teaching, which assists lecturers and professors in the integration of e-learning in everyday teaching,
b. The Laboratory for Teaching and learning technologies in the Department of Human and social sciences he belongs to.

He is member of several national and international societies and cooperates as a volunteer in the review process of international scientific journals.

Among his most recent publications is the book *Teaching in the Knowledge Society: New skills and instruments for teachers* (IGI Global).

Marco Palma is full time professor of Latin palaeography in the Faculty of Humanities of the University of Cassino (Italy). His main research interests are the morphology and development of different scripts of books and charters in the Western Middle Ages (i.e., from the 6th to the 15th century). He is also working on the material aspects of manuscripts, as well as the transmission of classic and medieval texts before the invention of printing. He is particularly interested in the theoretical and practical problems of the description of medieval manuscripts, and the diffusion of scientific information and didactic contents through the Internet. The open catalogue of manuscripts, his recent main project, conceived some years ago along with Antonio Cartelli, was so far realized by two historic libraries in Italy (Malatestiana of Cesena and Lancisiana of Rome).

A

An Academic Guidance Model to Orient Distance Students

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INTRODUCTION

In the last 20 years, the increasing importance of information and communication technology (ICT) induced many educational and training institutions to apply new technologies to education, in order to reach new and more ambitious goals (Hodgson, 2002; McNaught, 2003).

Academic institutions are following this same direction too. In Italy, as well as in the rest of Europe, we are witnessing the development of many experiences in *Web-enhanced learning* (traditional classes are taught, but there are online resources to complete the personal study), *blended learning* (teachers integrate traditional lessons with *e-activities*, such as online discussion groups, video conferencing and online resources) and, even if it is not so widely spread yet, *pure e-learning*, in which all the teaching process is Web based.

This chapter begins with an analysis of a distance degree in psychological sciences. The structure of the course includes a national centre, faculties of different universities, and technological centres. The technological centres, located both in Italy and abroad, are facilities available to students, and are equipped with all the technology necessary to follow the distance courses (personal computers, satellite connections, internet connections, etc.). These locations constitute actual meeting points for students, teachers and tutors, thus allowing for face-to-face exams and seminars, as well for videoconferencing. The student is guided by a new figure, the *e-tutor*, who facilitates online learning and communication processes.

The approaches to teaching and learning are both synchronic (by chat and videoconferencing) and diachronic (video lessons, practical exercises on the Internet, discussion forums, blogs, newsletters, etc.).

In order to understand the role played by technologies in a distance degree, starting from the very first steps taken by a student in the academic system, we will begin with the description of a guidance model conceived to inform, prepare and support the student during her or his academic career (Gresh & Mrozowski, 2000; Luck, 2000; McNaught, 2003; O'Donoghue, Singh, & Green, 2004). Then we present some theoretical, empirical and methodological issues about the use of new technologies in distance education. We conclude that a specific preliminary informative orientation system can prove to be a good tool to prevent e-dropouts, but on the condition that it starts from the very beginning of their academic career (Bozarth, Chapman, & LaMonica, 2004; DeRouin, Fritzsche, & Salas, 2004; Jones & Laffey, 2002; Lynch, 2001).

A three-step model is presented. The first step is "orienting", where a general exploratory guidance is given, describing the set of educational and technological instruments. In the second step, "preparing", the main goal is to reduce the technical gap between the student and the educational setting. Finally, the third step is aimed at giving technical, educational, and relational support to the student all along his/her academic career.

THE ORGANIZATIONAL PERSPECTIVE: THE STUDENT AND THE EDUCATIVE INSTITUTION

Everyday, researchers in the field of education witness the increasing use of technology in learning, and the spread of computer mediated communication in knowledge management (Jones & Laffey, 2002; Pan & Scarbrough, 1999). Very often a "naïve" use of technology is not appropriate, since it does not integrate three important elements: the student's profile, the educational system, and the organization.

The first element is a very important one for our purposes. We need to know many important data about the student (or about the individual within the organization); in a previous paper we called this concept the *extended training profile* (Vanin, 2006).

The extended training profile includes the following information:

- General personal data (age, gender, place of birth, etc.)
- Educational and training profile (school, professional and academic degrees, master courses and specializations, etc.)
- Technical profile (ability of using technical instruments and informatics skills)
- Interactive profile (habits in accessing technical equipments, in using the Internet, e-mails, discussion forum, chat, etc.).

With the concept of extended training profile, we suggested (Vanin, Castelli, Brambilla, in press) to increase the amount of information collected about students. Usually, this kind of information is collected only to answer bureaucratic and administrative requests; we suggest using it for didactical and training purposes too.

On the other side, the educational system depends from the educational institution and its organization (O'Donoghue, Singh, & Dorward, 2001). Pan and Scarbrough (1999), using a sociotechnical approach, give specific theoretical and methodological attention to the matching between social and technical subsystems. The authors outline three layers of interaction between individuals and organizations, taking into account the form of knowledge, the organizational context and structure, and the role of technology involved in the educational or organizational process (Pan & Scarbrough, 1999, p. 362). According to these authors, the three main components of a knowledge system are:

1. **Infrastructure:** It is the "strong" element of the organization, composed by the hardware and software of the communication, the net of physical and communicational contacts between members. Pan and Scarbrough (1999, p. 366) define this structure the knowledge architecture, made up by human resources, organizational entities, documents, books, as well as the physical structure of offices and databases.
2. **Infostructure:** This level includes all the formal rules which govern the exchange of information between the actors of the organization and produce a specific code, used by the actors to understand, exchange ideas and give sense to cultural metaphors and common language. Pan and Scarbrough (1999, p. 367) stress the point that these rules can be both formal and informal and govern both the use and the access to information sharing ("who" can use "what" information). An example of an infostructural element is the (material, symbolic or virtual) path that information has to travel through in order to reach its destination.
3. **Infoculture:** This third level refers to the culturally based code that organizations have developed to fit in their specific social and cultural environment. These practices, rules, values and habits define the information sharing process and represent the meaning and the role played by information in the educational and organizational structure.

Jones and Laffey (2002) elaborate over this model and apply the same framework to educational organizations with massive use of e-learning systems, evaluating the opportunity of using e-collaboration or e-learning systems in order to share knowledge. In their study, these authors give specific attention to each single part of the model: for what regards infrastructure, they point out the importance of clearly perceived values and benefits of e-collaboration, especially to substitute old tools, the role of training, of expectations and attitudes, the need to experiment new tools and to create user-oriented and user-friendly systems (Jones & Laffey, 2002, p. 254). Regarding infostructure, attention must be directed to knowledge repositories and databases to simplify the information sharing process. For what concerns infoculture, designers have to work on leadership, on collaborative/cooperative organizational culture, on involvement and motivation (Jones & Laffey, 2002, p. 255).

In both these two models (extended training profile and Jones' and Laffey's model), the role of information in educational and organizational systems is very important, as is the complete integration of infrastructure, infostructure and infoculture to facilitate the exchange of information (Chou, 2003; Jones & Laffey, 2002; Moshinskie, 2002; O'Donoghue et al., 2001).

As mentioned before, the first component of our educational system is *infrastructure*, which includes 44 tutors (specialized in specific learning subjects), supported by administrative front- and back-offices (3 tutors working on orienting and supporting, and one didactical manager that coordinates the whole staff).

For what concerns the *infostructure*, all the administrative and didactical information are managed through the Web: Web sites, blog, F.A.Q. (frequently asked questions) are used to give static information (i.e., regulations, organizational information, etc.); discussion forums are the main technical instruments used to exchange the information in a dynamic way (both by asynchronous and synchronous methods).

Finally, *infoculture* is the most important part of an educational system. In our case study, we can define three main components of the educational organization:

1. **Completeness:** All information and organizational data (teaching programs, examination dates, informative and learning objects, etc.) must be complete, simple, unequivocal and unmistakable, with no repetition in different places (i.e., one information in one place);
2. **Students' autonomy is required:** The educational organization has the priority to develop a simple and complete information system, but it requires from students an ability in autonomously finding information, browsing the discussion forum, Websites, etc.
3. **Continuous support:** This policy can be enacted only by developing a student-centered education system, with the priority to orient, prepare and to continuously support all the informative and learning activities. This system must be also continuously monitored and constantly fed.

MAIN FOCUS AND FUTURE TRENDS

Orienting, Preparing and Supporting: A Model for an Online Informative Guidance

In any educational system informative guidance and preliminary orientation seems to be the first step to introduce students (or, more generally, individuals) in the educational process. In distance education this aim can be achieved by Web based tools.

In order to develop distance guidance tools and to integrate them with the organizational system (infrastructure, infostructure and infoculture), designers can follow three progressive steps: orienting, preparing and supporting (Figure 1).

The first phase is *orienting*, and refers to the capability of the informative system to meet informational demands of students. This information enable students to start building their own general view of the educational system (i.e., the characteristics of the course) and exploring the main components of the didactical system (Gresh & Mrozowski, 2000; Luck, 2000; Lynch, 2001; Scagnoli, 2002).

Contrary to what happens in a traditional University setting, in an university distance degree the focus is centered on overcoming the gap between organizational and didactical aspects (Web-based course characteristics, differences from traditional courses, main learning tools) and students' characteristics (requirements for admission, self-regulation, self-management, and availability to interact with other students). The main aim of this orienting phase is to provide good quality information for both students and the organization, stating "*what does the university ask to students*" (in terms of basic requirements, values, general and specifics rules), "*what opportunities are offered to students*" (in terms of professional development programs, post-graduate programs, career opportunities) and "*how the whole system works*" (in terms of interactions with the other main actors) in an explicit way. This latter category of information concerns the whole organization and all the variables connected with infrastructure and infostructure: information services, front office, library service, lecturers, teachers, tutors, didactic staff. This huge amount of information is completely manageable through Web-based tools. Instructions should be written to avoid physical presence, should be unambiguous,

Figure 1. Integration between educational systems and informative guidance.

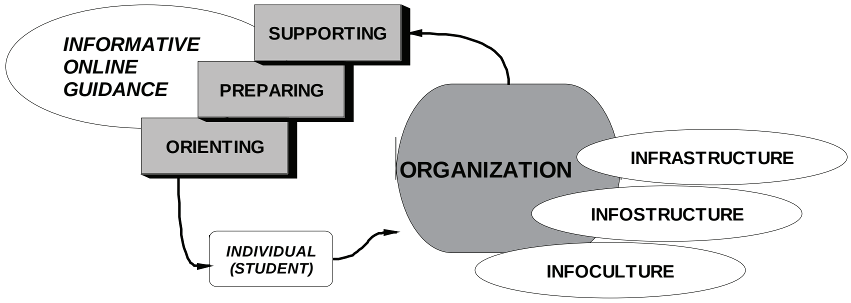


Table 1. Percentages of questions re-worked

Academic year	total n. of questions	questions re-worked	% questions re-worked
2003/2004	347	108	31
2004/2005	350	73	21
2005/2006	535	83	16
2006/2007	387	12	3

clear, pragmatic and, from an ergonomic perspective, fully accessible and usable (Chou, 2003).

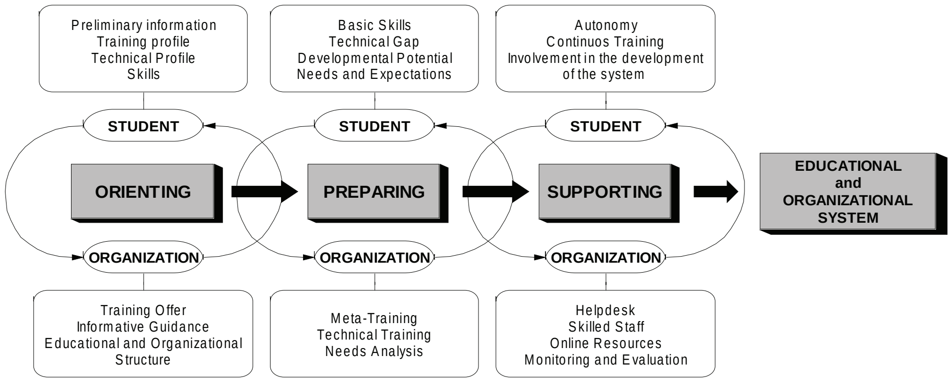
Of course, clarity and usability of orienting tools emerge from a long process of refinement, and are not the result of a single intervention. Arranged according the academic year, in Table 1 the number of questions arrived via e-mail at our front desk are shown, together with the number of questions which needed other e-mails to be completely answered (often, more than one email was needed). The percentage of e-mails which call for other e-mails is an obvious indication of low efficiency of the system, and Table 1 shows a continuous trend of improvement, rather than a single resolutive intervention.

The second phase (*preparing*) addresses students' needs concerning informative, didactic, and technological skills. Students often need to be trained to bridge the gap between the educational organization's demands and their skills (Bozarth et al., 2004; Hoffman, 2002; Jones & Laffey, 2002; Piskurich, 2003). Castelli, Vanin, and Brambilla (in press) define this training as a meta-training, and stress how often this part is neglected in e-learning, even though it could be a main cause of e-dropouts (O'Donoghue et al., 2004). Moreover, the orienting phase offers implicit indications (a sort of ethological imprinting) on self-management skills required to students, about the importance of interactions with peers and about basic skills concerning learning tools (Castelli et al., in press; Vanin, 2006); in the second phase, this imprinting becomes explicit and the *preparing* phase turns out to be a formal stage, a sort of buffer in which students gain operative knowledge of basic educational and technological tools (DeRouin et al., 2004; Gervedink Nijhuis & Collis, 2005; Luck, 2000; Moshinskie, 2002; Piskurich, 2003). The main goal of this phase is to reduce resistance to technology (Frazee, 2002; Frieden, 1999) through the improvement of technological skills for learners, in order to facilitate the process of sharing experiences and building knowledge through the transformation of experiences in understanding.

The last phase, *supporting*, includes activities aimed to offer motivational, relational and technical assistance to students during the whole academic year

A

Figure 2. Informative guidance as an integrated system



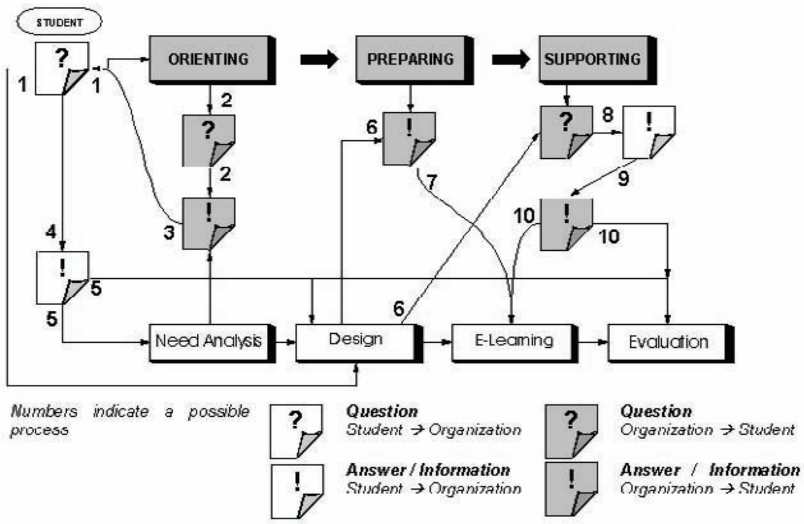
(Bozarth et al., 2004; DeRouin et al., 2004; Edwards & Fintan, 2001; Gao, Baylor, & Shen, 2005; Lee, 2001; Lynch, 2001). Web-based courses can exactly match students' needs in order to create conditions for an optimal learning experience.

As shown in Figure 2, the development of this kind of informative guidance model can encourage the entrance in the educational system, leveling off all initial differences (i.e., technical gaps between educational system and individual's profile), thus creating a common background to reduce the risk of e-dropouts (Booker & Rebman, 2005; O'Donoghue et al., 2004).

A consequence of this perspective is that selection procedures (when and if provided) and criteria should include all described aspects, in order to reduce possible "wrong expectations" (Vanin et al., in press). In our case study, for instance, we applied the extended training profile to explore needs and to detect problematic areas (i.e., gaps between students' profiles and the requests of the educational organization) in order to schedule extra training for beginners and/or to re-engineer our educational tools. A questionnaire is routinely administered to *all* would-be students who ask for information about our course before taking the admission test. Comparing this population of "potential" students of year 2006-2007 with the population of students already enrolled, we discovered only very small differences for what regards *general personal data*: most of them were female (66.0%; N=507), as it happens in "actual" students' population (56.7%; N=157). The age was between 18 and 65 years old (N=560; Mean=32.4; S.D.=8.73) in potential students and between 18 and 53 years old (N=157; Mean=35.2; S.D.=6.9) in students already enrolled. *Educational and training profile* showed that potential students (N=660) have mainly technical secondary degrees (59.4%), or a diploma in classical or scientific studies (29.6%). But the interesting thing was that only about 10% of them had some idea of what actually is "distance education". This entailed a deep revision of our guidance system, in order to correctly inform perspective students about the characteristics of this kind of learning technology. The *technical profile* was not very different between would-be students and actual students (the only real differences were the percentages of people owning a broadband connection and using Webcams, higher among actual students than in the potential students' population: but this could be an obvious effect of being enrolled to a distance course). The last part, the *interactive profile*, which refers to the informatics skills as well to the online interaction habits, proved to be very interesting: our students and perspective students rarely use the chat (57% never used, 36% sometimes). This means that we should avoid/reduce this kind of communication and/or start a technical training on this subject.

A second consequence is that the instructional developer should be aware of all the evidence thus collected, in order to enact strategies aimed to prevent and reduce students' drop out rates, which tend to be rather high in distance learning, especially in the case of students not linked to the educational network (Lynch 2001; Moshinskie 2002; Kotsiantis, Pierrakeas, & Pintelas, 2003). As shown in literature (Booker & Rebman, 2005; O'Donoghue et al., 2004), the "feeling of isolation" experienced by students and the sensation of no direct

Figure 3. The role of information in the informative guidance model



contact with groups of experts and other students may deeply affect learners' motivation, especially at the beginning of the educational process, when learners are not well inserted in the students' community.

Third, online informative guidance has a key position in all phases: as shown in figure 3 the "informative guidance system" is conceptualized as a dynamic interaction between information requested and information offered, in an integrated net that encompasses all the educational process.

This means that information is firstly offered by the educational organization (*orienting*: organization → student [section 1-5]), then information is reconstructed as an "answering system" aimed at reducing the gap between organizational demands and students' skills (*preparing*: organization →← student [section 6-7]), lastly, information becomes a specific answer to students' questions (*supporting*: student ← organization [section 8-10]).

Each phase is deeply connected with all the others by a structure of feedback, in which the whole educational organization offers guidance using both explicit and implicit students' requests (Vanin, 2006).

The primary objective of this structure is to offer information, but a key aspect of the model is that the university (or, more in general, the educational organization) should *at the same time* collect information to gain a better understanding of its audience, in terms of students' identities, knowledge production systems (intended as psychological and social artifacts) and active construction of meaning.

The proposed system collects information from each student, but it needs an accurate analysis of the educational structure (as a result of the integration of infrastructure, infostructure, and infoculture) in order to activate a developmental process that may (and should) try to reach all actors involved in the educational system.

CONCLUSION

This chapter examines a critical phase in distance educational processes and, more in general, in all organizational processes of knowledge building: newbies' entry into the system. Students can encounter many obstacles to integrate themselves within the distance training processes, so the whole system has to be customized to students' different needs.

A first set of problems is linked with the technical gap: educational and knowledge tools may represent an obstacle for many users (Spitzer, 2002), and organizations should not forget how this mismatch affects students' careers. Every kind of e-learning intervention should take into account the main infrastructural, infostructural and infocultural elements that could obstacle learning and teaching processes. A successful learning process start with an analysis of these elements, in order to dissolve technological, educational, structural and organizational barriers. The process of training involves in-depth analyses of needs, and course design should include a socio-psycho-technical study to prevent subsequent dropout (Bozarth et al., 2004; Lynch, 2001; Moshinskie, 2002; O'Donoghue et al., 2004).

A second issue concerns all informative and guidance tools conceived to welcome, to orient and to integrate newbies (or, more generally, students) within the educational and knowledge systems. We proposed a three-step guidance model, in which each phase is aimed to help individuals to manage a variety of educational, technical and interactive difficulties.

In the *orienting phase*, the educational system should create a knowledge network (i.e., Web sites, online documents, guides, and online tours) to inform would-be students about the project, the educational architecture and the main skills required. This phase represents both a first self-selection of students, and the first step of a welcoming system.

A *preparing* phase follows, in which students are put in condition to overcome technical and educational barriers, become acquainted with the learning tools and explore the online resources. In this phase students are helped to overcome the gap between their previous skills and the required extended training profile (technical skills, internet habits, general knowledge). This preparing phase could be implemented both by e-learning and traditional classroom training blended with online e-tivities.

Supporting is the last phase, and continues all along the educational (or knowledge management) process. It is aimed to solve all kinds of technical, organizational or educational hassles. It should not be limited to a first level of helpdesk functions, but rather requires developing guides built following a bottom-up strategy (i.e., frequently asked question), or online resources that guarantee continuous support.

Our model does not claim to be the "main solution" for e-dropouts. Indeed, instructional designers, technical developers and the educational staff must take into account many other factors (Booker & Rebman, 2005; Bozarth et al., 2004; Chin & Benne, 1985; Kotsiantis et al., 2003; Lynch, 2001; Moshinskie, 2002; Spitzer, 2002) to ameliorate learning processes, online interaction and integration along with the entire educational and knowledge system (Na Ubon & Kimble, 2002). People must be put in the condition to learn and technology has to be taken into account also as a source of significant gap (Gervedink Nijhuis & Collis, 2005; Gresh & Mrozowski, 2000; Hoffman, 2002; Jones & Laffey, 2002; Moshinskie, 2002; O'Donoghue et al., 2001; Spitzer, 2002)

However, in academic year 2006-2007, in our Distance Degree we had a dropout rate of about 24% from the first to the second year; this figure is low if compared with the general datum of our University (about 26%) but it turns out to be very good if compared with the general figure of 33% recorded among students who enroll "late" (i.e., after 20 years of age; it has to be noted that the average age of our distance students is 35.2 years). The system seems to work.

The three-step model, here described, allows students to obtain a gradual and fast insertion in the didactic system by putting particular attention on students' expectations and motivations. Indeed, in order to correctly overcome the potential difficulties, the model of informative guidance considers two principal factors: a detailed knowledge of students' identities (what we called *extended training profile*), especially for what concerns their technological tools and general skills, and the guarantee that the "informative guidance system" works as a primary "imprinting" for the development of a good e-learning path. In a retroactive perspective, the informative guidance system could also represent a good proposal to follow students along their "educational pipeline", adapting the system to their profiles, as well as asking participants to adapt themselves to the educational system (Vanin, 2006; Vanin et al., in press).

NOTES

* Luca Vanin: Conceived the main focus of the chapter, introduction and conclusions; Stefano Castelli: conceived the general plan of the chapter, and wrote the organizational background, introduction and conclusions; Loredana Addimando and Alessandro Pepe: did the bibliographic research and the in-depth organizational analysis.

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KEY TERMS

Extended Training Profile: Refer to the general personal information about students (age, gender, place of origin, etc.), educational and training profile, technical profile (capability of accessing technical instruments and informatics skills) and interactive profile (habits in using internet, e-mails, discussion forum, chat, etc.).

Infastructure: It is the "strong" element of the organization, composed by the hardware and software of the communication, the net of physical and communicational contacts between members.

Infoculture: Refers to the culturally based code that organizations have developed to fit their specific social and cultural environment.

Infostructure: Includes all the formal rules which govern the exchange of information between the actors of the organization and results in a specific code used by the actors to understand, exchange, and give sense to cultural metaphors and common language.

Online Guidance Systems: An online system allowing students or participants to e-learning process to understand what the educational process requires, which tools are used and to be informed of any kind of information about the organization, the educative model, and so forth.

A

Adaptation of Cognitive Walkthrough in Response to the Mobile Challenge

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INTRODUCTION

Cognitive walkthrough (CWT) is a usability inspection method which allows users to learn a system by using it to achieve tasks rather than studying a manual or documentation. It starts with a task analysis that specifies the sequence of steps required by the users to complete a task, and the system responses to those actions. The users then walkthrough the steps as a group and questioning themselves at each step. Data and information are gathered during the CWT and potential problems are identified. However, problems rose if the CWT and user based evaluation were being conducted in the mobile context environment. It became clear that static lab is not ideal for the CWT to be carried out by the evaluators to consider the behavior of the mobile interface, its impact on the user, and judge whether the user would be able to perform the tasks which features mobility. Although the CWT is suitable to be conducted during the early stage of the mobile device development because they can be performed using a system specification as a basis, the context factor that reflects the mobile challenge should take into the consideration at this stage and CWT should make adaptation in respond to this issues. This is due to that the evaluators will use the device in different ways depending on the situation such that the CWT might work fine in the controlled context environment without side influences or other context challenges factors, but it might not goes the same with the situation where the CWT is being conducted on the run or in the field. All the context consideration will have an impact for the usability solution and content suitability.

MOBILE CHALLENGE

Context Challenge

As the traditional usability tests on applications are being done using stationary computers, the context is controlled and not specifically relevant. The computers in the labs are more or less in the same context as when they are used in offices and homes (Lindroth & Nilsson, 2001). According to Johnson (1998), usability testing in a lab with controlled situations and tasks works for applications used in stationary solutions and this performs fine with the solutions where the context and environment is of second interest. For mobile devices, testing might make the result irrelevant since it fails to take the context of its use into consideration (Lindroth & Nilsson, 2001). However, problems rise since context plays an important factor for the usability testing of a mobile solution. The impact of use context to the usability of a product is strong and it is an especially important question in design of portable or mobile products, which will be used in several environments (Dr. Sade, 2002). According to Vaananen-Vainio-Mattila and Ruuska (2000), there are three levels of use context for mobile phones and communicators. The mobile infrastructure context deals with technical issues, such as the network coverage or low communication bandwidth. Second, the physical context is about: for example, noisy surroundings, the freedom of being truly wireless, varying physical usage positions, the demand for small physical size of the device, sharing one's attention between operating the device and other issues, the varying environmental factors concerning light, clothing and so forth. The third contextual dimension is the social context. The interaction is shaped by the need to take other persons into account—the ones who are communicating with the user and the ones who are in the same physical location with him or her. According to Howard (2003), there is another type of dynamic use context which is digital context for example the network infrastructure and communication with other devices. All these considerations have an impact on solutions for usability, physical ergonomics, the suitable types of content for the interaction channels and many other issues.

USER-CENTERED DESIGN (UCD)

User-centered design (UCD) approach aims at high-quality design and utilizes several methods to take users' actual needs and desires in account (Dr. Sade, 2002). UCD methods are one tool for creating devices and services that are really needed, useful, and suitable for the media. The cognitive walkthrough method of usability testing combines software walkthroughs with cognitive models of learning by exploration. It is a theoretically structured evaluation process in the form of a set of questions that focus the designers' attention on individual aspects of an interface and that make explicit important design decisions made in creating the interface and the implications of these decisions for the problem-solving process. The techniques that being used in UCD are classified into three groups—information gathering and analysis, solution generation and solution evaluation (Dr. Sade, 2002).

Solution Evaluation: Cognitive Walkthrough (CWT)

One of the expert inspection methods include cognitive walkthrough (CWT) which is a theory-based process where a group of evaluators go through a detailed description of the user interface. They have a task scenario and explicit assumptions of the user group and use context (Dr. Sade, 2002). CWT technique can be used to evaluate a complete system, a prototype, a system of which the user interface is not yet complete, or only a specification (Almedia, 2002). CWT method was designed to evaluate the learnability of software interfaces without the overhead of full-blown empirical usability lab testing and the CW can be applied early in the design process because it can be applied when only the user interface is specified- it is valuable for evaluating learnability of the integration of features when those features are at various stages of development. Before the CW session, the usability professional is responsible for defining the important user task scenario or scenarios and producing a task analysis of those scenarios by explicating the action sequences necessary for accomplishing the tasks in the scenarios and the first step to convene the walkthrough is to describe the goals of performing the walkthrough. CWT leads the designer to consider factors such as users' backgrounds, etc.

ADAPTATION OF CWT TO RESPOND TO THE MOBILE CHALLENGE

The main problem with the context adaptation is that the context cannot be easily identified or measured (Eija, 2002). However, context awareness is crucial in using the mobile device as it enables the mobile device to provide assistance based on the knowledge of its environment (Pascoe, Ryan, & Morse, 2000). It provides a method of automatically recording, presenting and filtering information through knowledge of the user's current environment. In addressing the context awareness problem while using CWT, few adaptations are suggested. Accordingly, the adaptation includes the following significant changes:

a. Instead of conducting the CWT in the lab for the evaluators to evaluate the mobile device, the activities should be carried out on the run in terms of field testing to expose the evaluators to the real mobile environment. Evaluators can go through the usability expert testing method by dealing with the context while considering other factors such as users' backgrounds, knowledge and etc. According to Lindroth and Nilsson (2001), evaluators might complete the task in different way if the test is being carried out outdoor instead of in the indoor controlled environment. In this way, the evaluators can deal with the technical issues such as network coverage or physical context such as noisy surroundings and varying physical usage positions. Evaluators can go through the CWT complete with interruptions, disruptions, and distractions as the influence of environment is often a critical factor in the usability of the device.
b. Some types of role players are being asked to interact with the evaluators while they are doing the CWT. A good example will be confronting with the evaluators as part of the test and take on different roles to share the evaluators' attention between operating the device, completing the task and some other issues. This will expose the evaluators to the social contextual dimension where the interaction is shaped by the need to take other persons into account. For example the ones who are communicating with the evaluators or the ones who are in the same physical location. Role-play is a method used when designing new

artifacts in the case where the evaluators do not have a mental model of such a "none existing" device (Lindroth & Nilsson, 2001).

c. One of the most common method used in Nielsen and Ramsay's evaluation of WAP in 2000 (Ramsay, 2000) is to let the evaluators observe themselves and write it down at a daily basis in a diary. This is one type of the ethnographical methods where the evaluators and the use of a mobile device are conducted in a real world situation. Diaries will be used to prompt the evaluators to reflect over their use of the device and compare to this result with the way they actually used it in role-plays.

d. According to Weilenmann, Alexandra, and Larsson (2000), the method suggested is to listen and watch the evaluators' behavior, movement and reaction when they are using the mobile device without their prior knowledge. Although this direct-observation method is intrusive and concerns about ethical aspect, this will be one type of situation where the device is used in the right context and right run while interacting with others.

e. According to Tarasewich (2002), increased demands on users' attention in dynamic environments can be addressed through interfaces that require less attention. The CWT should be conducted with the concept of trying to minimum the user interfaces attention (Pascoe, Ryan, & Morse, 1999) to generate the best results.

CONCLUSION

According to Rodden, Chervest, and Davies (1998), making use of the context of a device is important because it allows us to produce new applications based on the special nature of the context and helps to tailor standard applications for mobile devices. Interaction is no longer solely a property of the device but rather is strongly dependent on the context in which the device is been used. The CWT, as one of the usability inspection method starts early in the design process and giving the advantage as the earlier the critical design flaws are detected, the greater the chance that the prototype can be corrected. It helps evaluators to take on a potential user's perspective and therefore to identify some of the problems that might arise in interactions with the system. However, in using CWT to generate the results correspond to mobile device usage; the method should be adapted to cope with the mobile contextual challenges.

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KEYWORDS

Cognitive Walkthrough (CWT): It is a usability inspection method which allows users to learn a system by using it to achieve tasks rather than studying a manual or documentation. It starts with a task analysis that specifies the sequence of steps required by the users to complete a task, and the system responses to those actions. The users then walkthrough the steps as a group and questioning themselves at each step. Data and information are gathered during the CWT and potential problems are identified.

Context Awareness: It is originated as a term from computer science which sought to deal with linking changes in the environment with computer systems. It is used to design innovative user interfaces.

Field Testing: It is a type of testing that test a product in the actual context in which it will be used, as opposed to laboratory testing, or testing the product in its development environment. It is useful to identify the interaction problems.

Mobile Context Challenge: The impact of use context to the usability of a product is strong and it is an especially important question in design of portable or mobile products, which will be used in several environments.

Role-Play: It is a method used when designing new artifacts in the case where the evaluators do not have a mental model of such a "none existing" device.

Usability Inspection: It is a generic name for a set of cost-effective ways of evaluating user interfaces to find usability problems.

User Centered Design (UCD): It helps developers to find out the way users think, value and desire, thus allowing the designers to focus their development efforts correctly and to identify new potential product ideas. It aims at high-quality design and utilizes several methods to take users' actual needs and desires in account.

Adult Education and Adult Learning Processes with ICT

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INTRODUCTION

"Adult education"—involving planned and intentional learning opportunities that enable adults to acquire skills and knowledge they need to participate fully in the economic and social life of their community—takes place in both formal and informal settings, and provides clear pathways for learners to achieve their goals and objectives (Recommendation for action, 2004). Adults would like to learn in order to improve their qualifications and to bring their skills up to date for a new line of work. Adults would also like to learn because of the rapidity and constancy of change in society and because of life-long learning dealing with changes in lifestyles or value systems.

Brookfield (1995) has identified four areas as representing unique and exclusive adult learning processes: (1) *self-directed learning* (which focuses on the process by which adults take control of their own learning—in particular, how they set their own learning goals); (2) *critical reflection* (which is the idea of the decade for many adult educators who have long been searching for a form and process of learning that could be claimed to be distinctively adult); (3) *experiential learning* (which is based on the notion that "experience" is the adult's continuing process of evaluating experiences); and (4) *learning to learn* (which is the ability of adults to learn how to learn to become skilled at learning in a range of different situations). Brookfield has further noted that one of the trends in the study of adult learning that emerged during the 1990's, and that promises to exercise influences into the 21st century, might be the ways in which adults learn within the systems of education (distance education, computer assisted instruction, and open learning systems, for instance) that are linked to technological advances.

BACKGROUND

The "new economy" implies a society in which information communication technology (ICT) is changing the nature of the workplace and contributing to more efficient and productive practices geared toward enhancing the equality of both products and services (Brown, 2003). As the new economy increasingly requires people to learn new knowledge and skills in a timely and effective manner, the advancement of computer and networking technologies are providing a diverse means to support human learning and cognition in a more *personalized*, *flexible*, *portable*, and *on-demand* manner (Zhang, Zhao, Zhou, & Nunamaker, 2004). The new economy—which is an increasingly "global" economy—"is a term that was coined in late 1990s to describe the evolution of the United States from an industrial/manufacturing-based economy into a high technology-based economy, arising largely from new developments in the Internet, telecommunications, and computer sectors" (Wikipedia, 2006, ¶1).

Adult education has emerged as an increasingly important component in education policy and planning; the 1980s and the 1990s were a period of rapid development in adult vocational education and as a result of the structural change in industry and the labor market, "life-long learning" has become an important principle underpinning education policy (Ministry of Education Finland, 1999). Open and online education is a growing force in life-long learning. Due to the rapid development of Web-based technologies, increasing bandwidth, decreasing costs, and widening access, online programs of distance education are becoming increasingly popular teaching strategies for higher education to adopt (Townsend & Wheeler, 2004).

Adults learn in many ways—both in academia and in the workplace—through repetition and reward (behaviorism), through the help of mentors (social learning theory), through building upon previous experiences (cognitive theory), and through meaningful and relevant experiences (andragogy and humanistic theory): "Adults, for whom life-long learning is a fact of life, are commonplace in college classrooms…often bring a wealth of real-life experiences with them to the classroom, experiences that need to be recognized and integrated in the learning process" (Brown, 2001, p. 3). ICT, especially the Internet, is an indispensable *tool* or *environment* to enable adult education to face its new practices and challenges. The interrelationship between knowledge and skills and its impact on what adult learners bring to the classroom and then what is added to that and taken away is what lies at the root of higher education (Motteram, 2005).

NEW PRACTICES OF ADULT EDUCATION AND ADULT LEARNING PROCESSES WITH ICT

A paradigm shift is taking hold in American higher education, which includes the shift from "institutions of instruction" to "institutions of learning," creating powerful learning environments, improving the quality of the exiting students, and viewing faculty as primarily designers of learning methods and environments (Goetz, 2004). The current shift towards computer-mediated teaching and learning does place college and university professors under enormous pressure to gain expertise not only in emerging new media, but also in the innovative pedagogical approaches (Creanor, 2002): "The acquisition of empathic and pedagogically appropriate skills for the online environment must now come high on the list of teaching competencies" (p. 57).

Adult Learning Processes and ICT

As previously stated, self-directed learning, reflective learning, experiential learning, and learning to learn are major areas representing the post-war preoccupations of adult learning researchers; each area has its own internal debates, yet the concern and interest of those working within each of them overlap significantly with those of the other three (Brookfield, 1995).

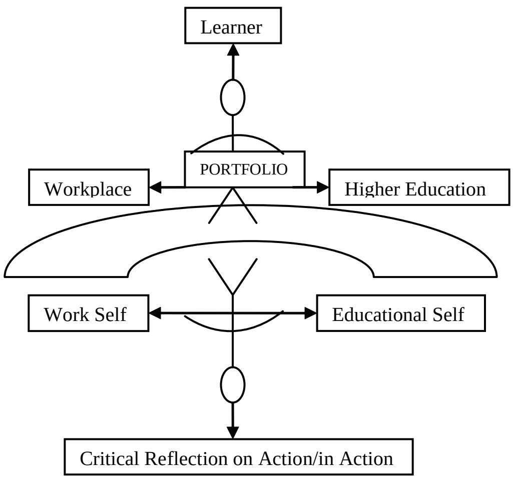
Self-directed learning. There are many synonyms used for computer-mediated learning (such as distributed learning, e-learning, distance education, and online learning). Online learning has obvious disadvantages (e.g., the impersonal nature of learning, and technical problems including breakdown in multimedia software and insufficient processor speed) but has advantages (e.g., flexibility in length and time of study, automated assessment and feedback, and discussion between remote users, which facilitate *self-directed learning*) (Medford, 2004).

Based on the notion that e-learning can empower adult students' ownership and self-directed learning, Lim (2004) defines five stages of the inquiry-based learning process: (1) Ask (learners articulate their own problems or questions); (2) Plan (learners design their problem-solving strategies within a certain time frame); (3) Explore (learners explore resources for solving problems using their background knowledge); (4) Construct (learners synthesize resources and provide solutions); and (5) Reflect (learners discuss the implications for further refinement). An important principle of life-long learning is the ability for *self-direction* (Flores & Flores, 2003).

Reflective learning. One critical element in the transformation of experience into learning is the process of reflection; the development of a "portfolio," due to its very nature, requires adult students to reflect critically on the *what's*, *how's*, and *why's* of their professional and personal learning so that they may describe and explain it to faculty evaluators (Brown, 2001). As Brown further describes, the portfolio can promote holistic learning by serving as a reflective bridge between the learner, the workplace, and the academy (see Figure 1). Learning and knowledge acquisition occur neither solely in the classroom nor exclusively in the world of life experiences or the workplace : "Holistic learning requires the integration of knowledge from multiple settings, and belief that knowledge is forever changing and ongoing throughout one's life. Learning from experience requires both reflection and reflexivity" (Brown, 2001, p. 10).

Electronic portfolios (e-portfolios) are increasingly popular now; and, an important direction for e-portfolios is that created with software tools found on computers or Web-based storage systems generally accompanied by data management systems that allow assessment of portfolio data (Gibson & Barrett, 2003). Web-based assessment systems support consistent, secure storage and aggregate reporting of assessment information. E-portfolios enable a powerful means for using it as a platform for linking with future learning; and additional pages can be added (e.g., additional artifacts can be

Figure 1. Model of the portfolio as a reflective bridge connecting the learner, higher education, and the workplace. Source: Brown, J. O. (2001)



archived and linked, and the currently stored evidence of learning will provide a rich resource for reflection as the adult student's learning journey continues).

Experiential learning. The rising demands of the new economy with rapid ICT advances and an ever-changing knowledge base have underscored the need for learning throughout one's life and the separation between *work life* and *school life* is diminishing (Brown, 2001):

In spite of the vast differences among psychological, sociological, and educational theories on how learning occurs, one idea appears critical—the role that the learner's life experiences plays in the learning process. Whether external or internal, cognitive or affective, individual or collective, experience, and learning are connected. (p. 4)

Adults enrolled in colleges are particularly interested in knowing how new knowledge relates to what they already know (Whiteman, 2002): "Effective approaches to helping adults learn include contributions from the students and their involvement in *what* is being taught and *how* it is being taught" (p. 7). As an example of effective approaches—in striving to be a facilitator rather than a teacher—a professor should ask basic questions to stimulate a discussion on essential concepts that allow adult learners to achieve competency in the content area (Inoue, 2002-03).

Technology, as Boerner (1999) states, can benefit the service-learning (complements academic work but is not directly connected to a course) process in three ways: (1) recording the experience for later reference; (2) creating a "virtual" community of participants such as students; and (3) "enabling" new avenues for the community to reach its goals. Communication, especially via the Web, can be thus implemented at a variety of levels, and a number of case studies of the use of technology as both a process and a product will be disseminated and shared.

Learning to learn. Among the various difficulties that educational institutions face in introducing the use of ICT to enhance the quality of learning through access to the resources and services that Internet technology allows, are not only the surrounding myths and resistance to change but also the necessary strategies and plans of action of the main actors in the educational process (Ruiz, 2005). Virtual learning environment (VLE) (similar concepts of open and distance learning, such as telematics learning environment, distributed learning environment, and e-learning) is a way that allows the process of learning without necessarily coinciding in space and time; VLE transforms into open spaces of learning so that the work of the teacher changes radically and the adult should be able not only to learn new knowledge but also *to learn how to learn*. Problem-based learning (PBL) is an educational approach that challenges adult students to "learn to learn." Students work cooperatively in groups to seek solutions to real-world problems, and it is more important that they develop such skills as inquiry skills, reflection skills, and assessment skills to become self-directed learners. That is why the goal of PBL is viewed as learning for capability rather than learning for the sake of acquiring knowledge.

Adult Literacy Education and ICT

Although most dictionaries define "literacy" as the ability to read and to write, the definition has been expanded and currently many consider literacy to be the ability to locate, evaluate, use, and communicate with a wide range of resources including text, visual, audio, and video sources. ICT training is often seen as a major motivator for adults to develop literacy, numeracy, and language skills and is an increasingly popular way to acquire these and other skills. Teachers *do* when they are using ICT for adult literacy and numeracy in the following ways (NRDC, 2003):

- **Using ICT:** The predominant pattern of activity is for learners to use a desktop computer on their own with the teacher either talking to the whole class, or involved in a group discussion.
- **Teaching ICT skills:** Talking about a procedure, demonstrating it and then asking the students to try it on their own is the most frequent mode of teaching ICT skills, and encouraging learners to experiment and discover for themselves how the software works.
- **Learning styles:** The visual elements of ICT presentation are useful to many learners; individual work and group work are the dominant styles but small group work is encouraged in some literacy and English for speakers of other languages (ESOL) classes.

A study by Snyder, Jones, and Bianco (2005) on adult learners' digital communication practices and implications for adult literacy programs found the following: E-mail, electronic chatting, and text messaging on mobile phones used extensively within adult education programs; and these modes of communication, each of which involves discrete literacy practices, were intrinsically interesting to learners. Working collaboratively with communities to design programs that respond to learner characteristics and labor market demands, and that integrate the literacies needed to handle contemporary multi-modal formats, is the ingredient for the success of adult literacy education. As noted by Snyder et al. (2005), institutional ICT policies are most effective when they are sensitive to the special needs and difficulties of disadvantaged groups. The federal vision for adult basic education learners is to ensure access to high-quality instructional materials and ICT resources through technology applications. The National Literacy Act of 1991 sets forth a vision for a literate society to enhance the literacy and basic skills of adults, and to ensure that all adults in the United States acquire the basic skills necessary to function effectively and achieve the greatest possible opportunity in their work and lives (Lovell, 1998).

FUTURE TRENDS

One challenge in adult education is that of adapting "student-centered approaches" to VLEs, and the following future trends can be highlighted:

- **Life-long learning:** Open and life-long learning is a frontier created by online learning communities; and, universities can help adults to become life-long learners, recognizing that educational/learning opportunities are available throughout their lives. Online distance learning provides answers to the problems of availability (accessibility and cost) and the demand for flexibility (time, place, and pace) of higher learning; technology-mediated learning and distance learning will become major vehicles for fulfilling the needs of life-long learning (Beller, 1998).
- **Constructive learning:** Constructivism "views the central problem in explaining cognitive development as one of understanding how the mind succeeds in constructing relationships among objects and events" (Lefrançois, 1999, p. 48). Constructivism also views that human beings *are* active learners who construct their knowledge on experience and on their efforts to give meaning to that experience (Frank, Lavy, & Elata, 2003). Therefore, constructive learning (thus the teacher's role is seen as aiding students' construction of knowledge) might be an appropriate and relevant theory for practice in the electronic information age particularly.
- **Paperless learning:** Future higher education courses, as Koepke (200) maintains, will be increasingly paperless and all course materials (syllabus and assignments) will be included on a course Web page, so that students can visit the Website that will become an "open door" to the classroom. Right now, professors try to create a sense of community in the classroom; in the future, the Website will create a sense of community among class members, and it will become a great way to inform and engage students across the curriculum in what this class is doing.

CONCLUSION

Modern life style requires new methods for life-long learning based on access at every time and from every place; especially Internet-based learning increasingly will gain importance in the future for life-long and adult continuing education (Hutten, Stiegmaier, & Rauchegger, 2005).

The confluence of the need for continuous learning and unprecedented technological innovation in communications has pushed online distance education approaches to the forefront of educational practices (Garrison, 2000). Higher education faces an era of mass graduation at a time of rapid ICT development and deals with five issues: (1) *access* (with ICT, higher education can widen access to include students at a distance); (2) *engagement* (promoting engaging learning and enquiry using ICT); (3) *community* (through online communities, ICT can be used to promote community); (4) *pedagogy* (ICT provides an opportunity for rethinking the curriculum and developing the pedagogy for adult learners); and (5) *cost* (some propose that ICT might be used solely to reduce unit costs and to capture a growing international market but some view that changes in the use of ICT in higher education are slow) (Millwood & Terrell (2005).

Finally, ICT—an indispensable tool or environment to enable education to face its challenges for adult learning—is a "skill for life" along with good reading and math skills (NIACE, 2003).

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KEY TERMS

Adult Basic Education: A process by which adults obtain their life skills training, citizenship and employability skills, such as training in job readiness, job skills, job seeking skills, basic computer skills, and job retention activities, so that they can participate fully in society.

Computer-Mediated Learning: In the context of teaching and learning, the use of electronic mail, computer conferencing, and the Internet to deliver learning material and provide learners and instructors with opportunities for interaction. It is also called Networked Learning.

Distance Learning/Education: It occurs when the instructor and the students are in physically separate locations. It can be either synchronous or asynchronous and can include correspondence, video or satellite broadcasts, or computer based online education.

Distributed Learning: It emphasizes learning rather than the technology used or the separation between teacher and learner; distributed learning makes learning possible beyond the classroom and, when combined with classroom environments, becomes flexible learning.

Life-Long Learning: A conceptual framework within which the learning needs of people of all ages and educational and occupational levels may be met, regardless of their circumstances.

Technical/Vocational Training: Training that is designed to prepare technicians, middle management and other skilled personnel for one or a group of occupations, trades or jobs.

Virtual Library: Library resources (indexes, journals, and reference materials, for example) or online reference services are available over the Internet. Terms such as Electronic Library and Digital Library are often used synonymously.

An Alternative Learning Platform to Facilitate Usability and Synchronization of Learning Resources

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INTRODUCTION

The Internet was initially set up in the 1960s and 1970s for supporting research in the military. It was then developed in 1981 in the academic community to connect university computers to enhance communications between academic researchers so that they could efficiently exchange ideas about the ongoing research (Coyle, 1997). Files transfer protocol was frequently used for transferring of files and computer-mediated communication (CMC) was also popular in the education context. Formats of CMC include e-mail, bulletin board, and list servers. With the decreasing hardware and data communication costs and increasing bandwidth, the Internet has altered our options for living, studying, working, and entertainment. It appears to be the most powerful information technology tool for education in the 21st century. There are many reasons for its popularity, and the main reasons can be attributed to accessing information easily, freely, and speedily. It provides powerful search functions, enables synchronized communication such as video, audio conference, and chat, and enables multiple presentation formats such as animation and video streaming without any add-on software or hardware. In fact, the Internet is more than technology, it is a Web of social relations imaginatively constructed by symbolic processes initiated and sustained by individuals and groups.

Many universities are tapping into flexible ways of learning, and some universities provide comprehensive services for preparing educators for electronic learning (Huyng, Umesh, & Valacich, 2003; Shea, Fredericksen, Pickett, Pelz, & Swan, 2001). Insightful individuals and companies have thus blended the unique functionalities of the Internet and learning resources and developed consolidated learning systems called learning management systems (LMS). Different authors and companies have termed LMS in different ways; for example, it is called course management system; managed learning environment; virtual learning environment; Web-based learning environment and learning platform, and e-learning system. Recently, the term "learning platform" has become more commonly known than LMS. Typically, learning platforms act as a resource repertoire and usually have three areas, namely, content area, communication area, and administrative area.

Learning platforms help educators and administrators manage learning resources, promote interactions among learners and between learners and educators, and enable teachers or administrators to track and report learning outcomes. There are a number of learning platforms in the market, but the most popular ones are WebCT (http://www.Webct.com/), Blackboard (http://www.blackboard.com/us/index.aspx), and TopClass (http://www.wbtsystems.com/). Apart from those commercially developed learning platforms, there are also a number of free-learning platforms available which are usually sponsored by governments and large organizations. Moodle (http://moodle.org/) is perhaps one of the rare free open source software packages that allows individuals to modify it for their use.

BACKGROUND

Learning platforms are widely used as learning portals to allow students to learn at any time and any place as long as there is an available Internet connection and a standard Web browser (Boggs & Shore, 2004; Freeman, 1997; Palloff & Pratt, 2001). They can use the online platform to participate easily in discussion forums and access teaching materials and related Web sites online. Many research studies suggest studying partially online enhances learning. The benefits include improving the quality of learning (Alexander, 2001), learners' levels of involvement, and incentive to learn can be increased significantly with a wider and more complete understanding of the subject knowledge (Eleuterio & Bortolozzi, 2004); to be able to discuss in greater depth; the enhancement of critical thinking skills (Tan, Turgeon, & Jonassen, 2001); and to foster active and independent learning (Rosenberg, 2001). However, Alavi and Lediner (2001) did not find any conclusive evidence after reviewing pertinent literature and suggested that better understanding of the role of technology is needed.

Functionalities of Learning Platforms

The components of learning platforms usually include templates for content pages, discussion forums, chat, quizzes, closed-end exercises, and control panels. Most course instructors put teaching materials on the content pages as it provides a central area for storing teaching materials systematically. The materials can be Microsoft PowerPoint or other acceptable formats. However, the discussion forum can be considered the most important function of a learning platform as it facilitates discussion. All learners have full control of the duration and time to discuss whatever and whenever they feel like it. The opportunity to participate is invaluable to learners as it is usually impossible for everyone to participate in discussion during class time, especially with larger classes.

Learners are prompted to think deeply and are more reflective when posting their messages online. This is because the postings are there for everyone to read so that they have to be mindful of their own opinion. Research has also found that learners consistently rate communication and support from educators and learners as being a major influence on their learning (Fredericksen, Pickett, & Shea, 2000; Sims, 2003). In fact, a discussion forum is more than just a place for communication; it also serves as a record of participation. However, incentives are needed to motivate full participation. The main welcoming incentive appears to be giving marks for online discussion. Other incentives include giving encouraging feedback and some forms of tangible reward such as giving chocolates for good quality discussion and/or frequent discussants. Ideas and examples of what to put in a learning platform are shown in Table 1.

Limitations of Learning Platforms

Although a learning platform can assist educators in systematically creating and managing their teaching material, many popular Web-based learning platforms have limitations such as the lack of facilities for the reuse of teaching material. Indeed, the educator has to upload the same file twice if she uses the same teaching material for two different modules, even for the same

Table 1. Examples of resources of a learning platform (Blackboard)

Function	**Example**
Announcements	General announcements such as change of teaching venue and cancellation of classes
Course information	Module syllabus
Course material	PowerPoint files Word files Short video clips
Assignments	Assignment requirements and submission deadline Marking scheme Assessment rubrics
Discussion forum	Open discussion according to the topics related to the module content. Intergroup discussion on the topics chosen, facilitated by different groups. For submitting assignments as a form of formative assessment so that comments from peers and educators can be collected and recorded.
Groups	To share private exchange of files, information, and communication within the group members (particularly appropriate for group projects). Formative assessment among group members such as draft of the group's work and reflection on what they have learned from the module. Informal information exchange among group members.

semester. Therefore, the educator may need to keep and manage that file in his local computer in a different folder so that he could easily find the file for future reference. This one-to-one approach also increases the necessary storage space and degrades the performance of the server.

At present, the popular learning platforms do not provide multitasking functions. Students can only browse the material one piece at a time. Teaching material such as videos and slides are played independently, and students might become lost when trying to map the slide pages with the video contents. Yang and Liu (2005) summarised the limitations of learning platforms: (1) there is no synchronization and matching between course materials and their explanations. There is possibility of mismatch between the explanations provided in the Web-based learning system and any other learning materials that learners might use; (2) there is a lack of standards' descriptions and reusability as some Web-based learning systems are built according to the owner's personal requirements; and (3) there could be a lack of contextual understanding, instant feedback, and interactions among participants.

MAIN FOCUS OF THE ARTICLE

In view of the inefficiency and inadequacy of learning platforms, this chapter will discuss a self-made learning platform, named PILOT (Promoting Interactive Learning in an Online environmenT). PILOT enables users to use and reuse the uploaded material on demand and to allow users to select certain segments of the material and to synchronize different formats of teaching material (Ng & Lee, 2006). It was designed to provide a resource repertoire for learners to click and pick when creating learning material. The constraints of one-to-one relationship of different resources have been expanded to include a many-to-many relationship. Resources of different formats can be mixed and matched to provide an alternative learning environment. The platform consists of five areas, namely, material, presentation, quiz, forum, and personal information as shown in Figure 1.

The *material section* is for users to upload and manage material which can be of multimedia or PowerPoint format. Research into multimedia and related instructional technologies over the years has indicated positive effects on learning (Hede, 2002). Depending on

Figure 1. The front page of PILOT

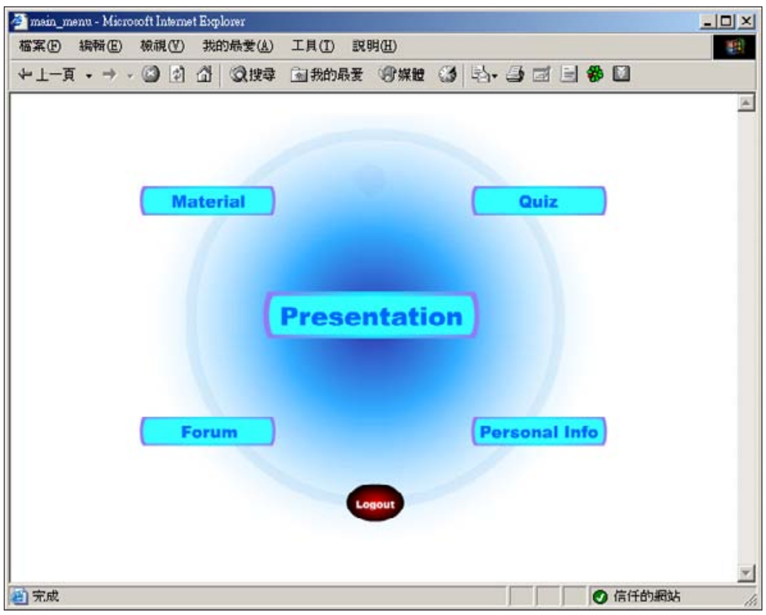
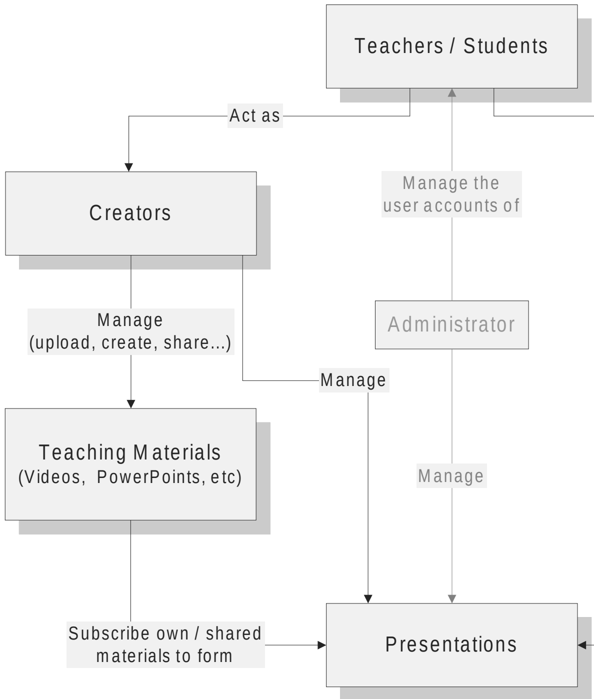


Figure 2. Organization of PILOT



the needs, users can be teachers or students as shown in Figure 2. Any user can decide whether to share or not to share the teaching material uploaded in the platform (Figure 3). The user may subscribe her own material or the material that had been uploaded by other users to form a new teaching material called "Presentation" in the *presentation section*.

Similarly, a user can create his own quiz or subscribe to others' quizzes in the *quiz section*. The quiz aims to promote active learning and enable interactivity with the material. Users can share their comments and raise questions about that "Presentation" at the *discussion forum section*. Finally, the *personal information section* is for users to change passwords. The following sections will illustrate how to make a presentation so that it would be easier to understand its functionalities.

Mix and Match Resources

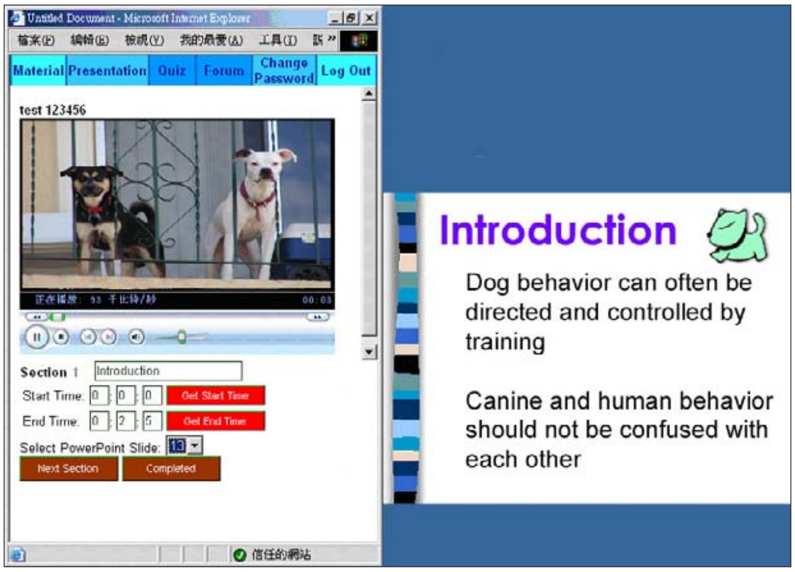
Creating multimedia learning resources takes considerable time, effort, and financial commitment. It will save a lot of resources if the material can be reused. Sometimes, it is impossible to use the entire resource due to the different emphasis and different learners' needs. If a user is using PILOT, she only needs to subscribe to the required video and PowerPoint and then specify the time intervals and the required slide numbers without the added effort of having to learn how to edit video using complicated or expensive software. For example, John wants to create a topic about small dogs. He finds that there is a video that is uploaded by Jill about different "Cats and Dogs" and a PowerPoint that is uploaded by Jane named "Pets." Since parts of these two files are relevant to John's topic, he can use both of them to form a "Presentation" without having to edit or delete any unwanted portions. The whole creation process is very simple: just search and pick teaching material from a pool and create tailor-made "Presentations." The actual steps will be explained in the next section.

Synchronization of Resources

The simple user interface of PILOT was created to facilitate synchronization of videos and slides. Although there is a plug-in which allows users to create

Figure 3. Searching materials at PILOT

Figure 4. Synchronize a video with a PowerPoint file



PowerPoint with synchronized video, it is inappropriate for educational use because the slide contents and the video are embedded together so that other users cannot extract any section out. When creating a "Presentation," the users are only required to input or get the start time/end time from the video and select the appropriate PowerPoint slide for that time interval (Figure 4), and a section will be created (a slide with the related video interval). For example, John can select 6 relevant slides from a 20-slide PowerPoint file and select 6 matching video sections of varied duration from a video file to form a "Presentation." The irrelevant 14 slides and video sections are skipped. If John cannot find a related PowerPoint, he can create a section slide with the "Slide Editor" online. He can also insert any images or to copy and paste HTML materials into the slide editor as shown in Figure 5.

Similarly, John can create his own quiz or subscribe to another's quiz in the *quiz section.* He can specify when the quiz will be displayed anytime during the execution

Figure 5. Synchronize a video using the slide editor

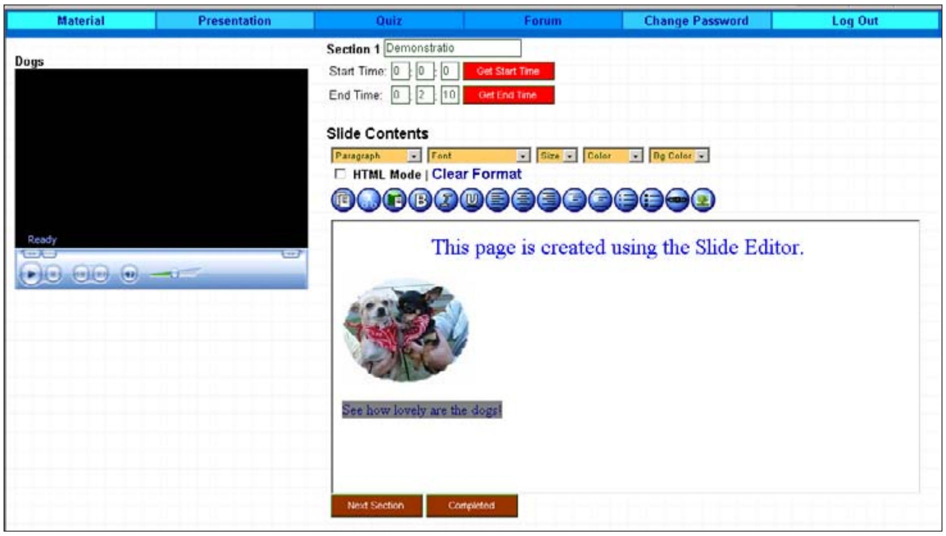
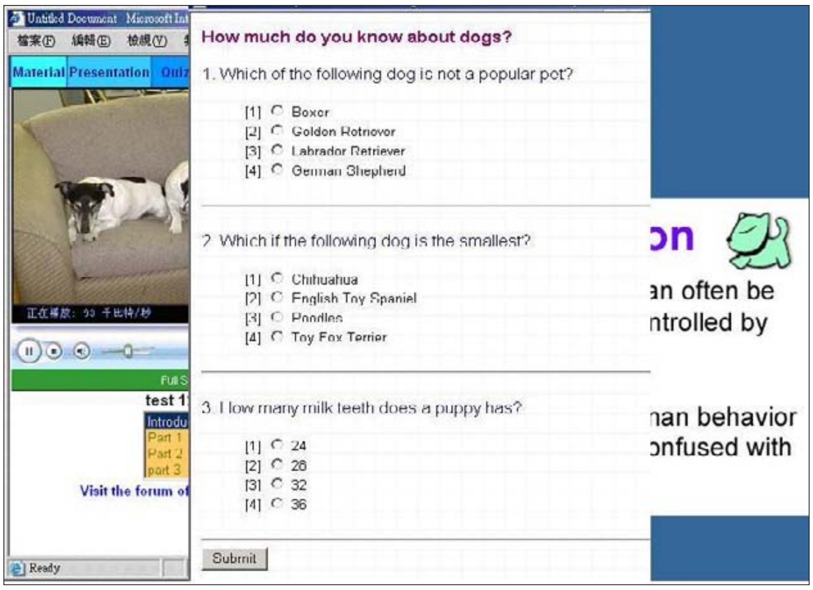


Figure 6. Synchronize multiple questions with a "Presentation"

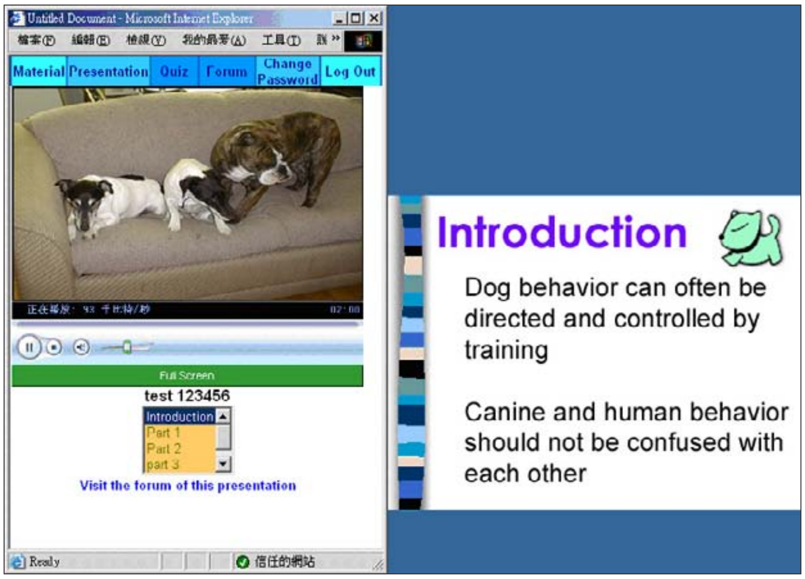


of the "Presentation" (Figure 6). The related discussion forum is also shown upon viewing the "Presentation." The *discussion forum* is an arena for exchanging and discussing pertinent problems and to form a learning community (Scardamalia & Bereiter, 1996; Tu & Corry, 2002). When a new "Presentation" is created, a new thread can also be opened in the forum. Learners can share their comments and raise questions about that "Presentation" when browsing or whenever they are logged into PILOT. "Networking opens up possibilities for enhancing formative feedback to students through peer review, when scripts are posted electronically for comment and review" (Macdonald, Weller, & Mason, 2002, p. 10).

Viewing of a Presentation

After a "Presentation" is created, learners can browse synchronized videos and slides. They can view the

Figure 7. Viewing a "Presentation"



"Presentation" sequentially or randomly. When a section is selected, the corresponding video time and slide contents will be shown (Figure 7). Learners can go backward or forward or pause at any time by click and pick as well. The advantages of displaying two files concurrently include the complementary synergy of information and to further prompt and stimulate learners to think while watching video content. Furthermore, they are provided with additional flexibility such as in selecting or revisiting any section of the video at any time. This flexible approach aims to promote active learning and enable interactivity with the material, as an essential combination in determining the extent of learning is the actions and interaction of the learners (Laurillard, 2002; Oliver, Omari, & Herrington, 1998). Thus, the learners have total control of the time, place, and pace of viewing a "Presentation."

Architecture of PILOT

PILOT operates under a Windows 2000 environment. Since it is still in initial usage, only one hardware server is used to perform Web, streaming, and database services. At the host side, three different components are used to handle different tasks. Internet information services (IIS) is used in order to provide Web services so that users can access it easily. ActivePERL is also installed so that PERL scripts can be executed (PERL is the main back-end programming language of PILOT). MS Structured Query Language (SQL) Server 2000 is equipped to provide database manipulations to store all teaching material, user information, and their subscriptions of different learning materials. A streaming service is also required to provide streaming video and audio hosting services. Furthermore, Windows Media Server is also installed so that PILOT users can browse streaming media using a standard Windows Media Player. On the client side, users are required to add the domain of PILOT as a "trusted site" in Internet Explorer so that PILOT can utilize ActiveX technologies through Javascripts, and PowerPoint slides can be synchronized with video contents.

When there is a request from a client computer such as log in, view presentations, and upload videos, PERL scripts are invoked. These connect to the database via open database connectivity and use SQL commands to fetch or update data in the database. When a file is uploaded or downloaded, it will call the database to store or get the file, except in the case of streaming media which are stored in the streaming area. Then PERL scripts will generate a HTML output embedded with Java scripts to the client. When streaming media is required, the client computer will be connected to the streaming server via Microsoft Media Server protocol.

Table 2. Feedback on user interface

User Interface	Strongly Agree	Agree	Disagree	Strongly Disagree
The user interface is consistent	29.17%	65.28%	5.56%	0.00%
This platform is easy to use	29.17%	62.50%	8.33%	0.00%
This platform enables users to edit and use teaching material flexibly	25.00%	68.06%	6.94%	0.00%

Table 3. Feedback on learning environment

Learning Environment	Strongly Agree	Agree	Disagree	Strongly Disagree
This system provides a comprehensive learning environment	30.56%	65.28%	4.17%	0.00%
Users can develop independent learning through using this platform	25.00%	66.67%	8.33%	0.00%
The synchronization of various formats of material creates high interactivities between the users and the platform	25.00%	66.67%	8.33%	0.00%
This system can foster active learning	15.28%	63.89%	20.83%	0.00%

An Evaluation

There were 72 participants who were taking an information technology in an education module in their first or second year of undergraduate studies. They were divided into three groups. They were given a brief introduction and demonstration of PILOT in their fourth week. They then followed the instructors in creating a synchronized presentation. They were also given an online user manual and a hard copy to follow the procedures to scaffold their learning (Oliver et al., 1998). They used the platform for about 50 minutes. Upon completion, they were prompted to answer an online questionnaire which was divided into two sections, namely the user interface and its functionalities. Table 2 shows that the results were very encouraging. A majority of the learners agreed that the interface of PILOT was consistent and easy to use. They also acknowledged the flexibility and reusability provided by the environment.

Table 3 shows that most participants agreed that PILOT provided a comprehensive learning environment. It was not only able to foster independent learning but also provided an interactive learning environment with synchronization capabilities. Learners were also generally positive with the questions that PILOT could foster active learning. Only a few disagreed, though this was probably due to the fact that they did not use the platform long enough to appreciate its functionalities.

To monitor whether learners actually paid attention during the practices, four questions which were pertinent to the functionalities of PILOT were also asked. The results were very encouraging as most of them scored the correct answers. Over 90% of the participants got a correct answer when they were asked about the functionalities of PILOT. 84.72% of the learners realized that they had to set PILOT as trusted site before they could use PILOT. 72.22% of them understood that PILOT did not support Word documents with video. Apparently, they had the least understanding of what formats PILOT supports (62.59% correct) which is understandable as they did not spend substantial time to gain experience.

Table 4. Questions on PILOT's functionalities

Questions	Answer 1	Answer 2	Answer 3	Answer 4
When we use PILOT to prepare a "Presentation," we can do the following	Insert pictures (8.44%)	Change the color of fonts (1.39%)	Change the font size (0%)	**All of the above** (90.28%, correct answer)
Before we use PILOT for the first time, what should we do?	Set Internet Explorer as a browser (13.89%)	**Set PILOT as a trusted site** (84.72%, correct)	Set PILOT as the first page (0%)	Set PILOT as e-certificate (1.39%)
PILOT does not include which of the following functions?	Discussion forum (26.39%)	PowerPoint with Video (1.39%)	**MS WORD and video** (72.22%, correct answer)	Question bank (0%)
PILOT does not support which of the following formats?	**mov** (62.59%, correct answer)	gif (18.06%)	wmv (16.67%)	ppt (2.78%)

FUTURE TRENDS

More and more educational institutes use learning platforms to complement face-to-face learning rather than replace it. Apart from providing synchronization and reusing learning materials like PILOT, the future trends would be to enhance the functionalities of learning resources, interactivities, and administration.

Learning resources: there is a need to standardize learning resources so that they could be portable and reused. The IEEE working group (http://ieeeltsc.org/wg12LOM/lomDescription) is probably one of the most promising groups in developing a standard, namely, learning object metadata (LOM) schema. The LOM standard specifies a conceptual data schema that defines the structure of a metadata instance, which can adequately describe learning materials and make them available for searching, management, and reuse.

Interaction: There are two main areas of interaction, one area is interaction among people, while the other one is interaction with learning materials. The learning platforms can provide synchronized communication such as instant chat, video conferencing with educators and among learners, lecture on demand (video taped of lectures), and instant anonymous voting. Another perspective of interaction is between users and learning materials such as giving them a "personal notes" area so that they can view and jot their own notes when browsing the learning materials.

Administration: To enhance personal administration of learning, searching and indexing functions can be added to learning platforms which enable learners to find related learning resources and information easier and faster. At present, the platform administrative functions can track the time and the duration of learner's activities using delivery. However, it would be hard to know if they are active or idle when they are online. Some pop up questions or messages/tips could be added to enhance interactivities and enable the system to know if learners are actually using the learning platform to learn.

CONCLUSION

This chapter has described how the Internet has made a significant impact on the mode of learning and how learning platforms assist learning systematically. The common functionalities of learning platforms were also described. Uncovering the limitations of the popular learning platforms has encouraged the author to develop a learning platform which embraces materials reuse, sharing, and synchronizing. The simple mix and match function of the platform has transformed diverse learning resources from one-to-one relationships to many-to-many relationships. Learners also have the flexibility to learn from different formats and to consolidate their knowledge through online quizzes which can be embedded into a "Presentation." They can learn according to their own time, place, and pace preferences.

Although there are a number of self-developed platforms which cater better for different educators' needs than commercially available ones, learning platforms merely provide a framework for learning. They cannot address individual differences. Apart from the aforementioned possible enhancement features which can be implemented in the near future, the next step will be to offer different levels of learning resources and quizzes according to different styles and cognitive levels. Some open-ended questions and wider variety of quizzes such as nontext based and mix and match types can also be added for variety and different needs. To conclude, learning platforms are merely learning tools. The crucial point is that it is important to integrate these learning tools into learning by using appropriate pedagogy and learning style recommendations in order to enhance learning effectiveness.

ACKNOWLEDGMENT

I would like to thank my colleagues, Dr. Kar Tin Lee and Dr. Siu Cheung Kong, for asking their students to participate in this study. All participants and colleagues who took part in this study are also appreciated. Very special thanks go to my research assistant, Lap Pui Lee, for creating such a wonderful learning platform and other research assistance, and also to John Coombes for editing effort.

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KEY TERMS

Computer-Mediated Communication (CMC): Any form of technology supported communication between two or more individuals. CMC mainly focus on social effects of different computer-supported communication technologies. With the availability of the Internet, many recent CMC methods involve Internet-based communication.

Learning Management System (LMS): A software package that enables the management and delivery of learning resources to students at any time and at any place when accessed from a browser. LMS enables students to study in a flexible and self-paced mode. Most LMS are commercially developed but there are some free LMS which cater for less privileged users.

Learning Objects (LOs): Defined as any entity, digital, or nondigital, which can be used, reused, or referenced during technology supported learning (http://ltsc.ieee.org/wg12/).

Multimedia: Multimedia is a medium that uses multiple forms such as animation, text, audio, graphics, and video to deliver information.

Synchronization: Synchronization means coordinating more than one medium so that they can be delivered interactively at the same time.

Ambient Intelligence

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INTRODUCTION

"Ambient intelligence" (AmI) refers to both a theoretical and a practical orientation of technology, involving the most innovative areas of the ICT sector. Recognized as a powerful trend, Ambient Intelligence has an increasing impact in several domains of our contemporary society, the so-called "knowledge society".

Let us look at the two words "ambient" and "intelligence". Today we often use the attribute *intelligent* or *smart* referring to artifacts that show "a behavior", have "a memory", appear to take nontrivial "initiatives". Take, for instance, a smartphone, which is able, when there is an incoming call, to put up on the screen the image of our correspondent. The "*intelligence*" in the words "Ambient Intelligence" precisely refers to those special embedded capabilities of certain things around us, capabilities that we are not aware of until they come into action. The word *ambient*, means "existing in the surrounding space" and signals that there is a particular diffused property of such a space. It has an essential charateristic, which is neither explicit nor obtrusive, but widely exploited by our Knowledge Society: the capability to transmit information without the need of wires (wireless communications). Like its underlying technologies, Ambient Intelligence is an expanding, evolving concept, projected far into the future.

Ambient Intelligence was born in the United States and will be about 20 years old in 2007. In its history there is a remarkable difference between the period in the past century, characterized by laboratory programs and military use, and the period in the new millennium, showing international projects, industry investments and a progressive spread into the consumer domain.

BACKGROUND

AmI borrows its theoretical foundations from a variety of external disciplines, among which sociology, ergonomy, cognitive sciences and human computer interaction (HCI) have a relevant role. A definition of AmI in formal terms will be provided, but the simplest way to see it is as a set of objectives aimed at human progress, to be met progressively, that is, a *vision*.

The AmI Vision and Its Pioneers

The AmI *vision* is due to an American citizen, Mark Weiser, chief scientist at PARC, the prestigious Xerox laboratory in Palo Alto, California, in the years following 1988. Weiser was deeply concerned with the relationship between man and *computing* (meaning all forms of computing power), and was worried about the blatant unfriendliness of the computer and its obtrusiveness. His vision, expressed in a well-known paper in the journal *Scientific American*, is crystal-clear:

> *The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.* (Weiser, 1999, p. 1)

The aim of Weiser was to render technology "non-obtrusive" (also dubbed in his papers: *calm*, *invisible*, *disappearing*), contrasting the contemporary hype for VR (virtual reality). VR constrains the individual by imposing the adoption of awkward devices (e.g., goggles, sensitive gloves) and isolates him from the world. Moving in a completely different direction, Weiser and his team designed and built many innovative devices meant to replace the role of the personal computer. Their inventions anticipated most of today's mobile communication tools.

Besides Weiser, two other scientists are recognized as AmI pioneers: Donald Norman, an American, and Emile Aarts, a European. "Don" Norman, a cognitive psychologist and one of the top usability experts in the world, continued in the direction of Weiser the criticism of the personal computer (Norman, 1999). He pointed out the carelessness in the design of the "industrial" interfaces, that is, all the interfaces interposed between man and the various electronic and nonelectronic appliances that surround him. Norman's thesis is well known, that when IT (information technology) is applied to objects for use, one of its key qualities should be "pleasurability" (Norman, 2003). Simplicity, versatility are also his keywords. His studies, for example his elaboration of the concept of *affordance* (Norman, 1988), are fundamental contributions to the AmI culture.

The period during which Norman's main works appeared, between 1999 and 2004, is also the time when the mix of ideas and studies around the "The Disappearing Computer" arrived in Europe and began to spread rapidly. "Building Disappearing Computers" (Russell, Streitz, & Winograd, 2005) had been an American vision, to which many high-profile scholars had applied themselves. Europe followed, and since then, in the Old Continent, the European Union has been giving ample support to the development of AmI. The very term "Ambient Intelligence" was coined in Europe at that time and ever since has been the name of this new and complex field of research and development. Ambient Intelligence is the merging of the American advances in computer technology and design principles (Winograd, 1996) with the European leadership in communications and Europe's strong concern about "lifelong and lifewide learning": the idea that technology should serve knowledge and that knowledge should be accessible by all social classes and at all ages.

The pioneer of AmI in Europe is Emile Aarts. He is senior vice-president Philips Research, senior scientist and scientific program director, Philips Electronics, Eindhoven, Netherlands. Aarts, a real champion for AmI, in many public occasions, with his books and through his own company incessantly advocates the AmI vision and its application in "everyday life" (Aarts & Encarnaçao, 2006; Aarts & Marzano, 2003).

This is our vision of 'ambient intelligence': people living easily in digital environments in which the electronics are sensitive to people's needs, personalized to their requirements, anticipatory of their behavior and responsive to their presence. (Philips Research, 2006, p. 1)

Philips is one on the leading company investing in AmI, but there are other leading-edge enterprises in this area, for example, Nokia, Vodafone, and Siemens in Europe; Intel, Microsoft, Sun and HP in the United States: NTT and Mitsubishi in Japan, as well as all the major car manufacturers worldwide.

Because of its evolutionary quality, amazing coverage of different disciplines and representation of new inventions, the knowledge about AmI is mostly located in the web and only very little material is available in print. At the same time, the number of international research centers and research groups that deal with AmI is very high, extending into most countries in the world. An indirect list can be obtained by consulting in print the projects projects presented in the very comprehensive book about AmI by Aarts and Encarnaçao (2006).

AMBIENT INTELLIGENT IN THE APPLICATION DOMAIN

AmI has been said to be the "megatrend" of ICT. Being a global trend with a wide scope, it involves numerous application domains and it is as pervasive as the technologies that underlie it. To move AmI out of the isolation of the research field, one key step was made 1999 by ISTAG, the advisory group to the European Community's Information Society Technologies Programme, which produced a fundamental report, giving a strategic orientation to all future IST programs. It is still current today:

The vision statement agreed by ISTAG members is to **"***start creating an ambient intelligence landscape (for seamless delivery of services and applications) in Europe relying also upon testbeds and opensource software, develop user-friendliness, and develop and converge the networking infrastructure in Europe to world-class.* (ISTAG, 1999, p. 1)

The next event was the creation, by a large group of experts guided by the Institute for Prospective Technological Studies (IPTS, 2006), of a set of model application scenarios conceived to take place at the horizon of the year 2010. The document "*ISTAG, Scenarios for Ambient Intelligence in 2010 - Final report*" (Ducatel, Bogdanowicz, Scapolo, Leijten, & Burgelman, 2001) is a fundamental milestone for AmI and an absolute reference for the entire AmI community.

Ambient intelligence is understood as the sum, or convergence, of three continuously developing technologies:

Figure 1. The Ambient Intelligence environment (Source: Fraunhofer-Verbund Mikroelektronik)

- **Ubiquitous computing:** The integration of microprocessors into everyday objects like furniture, house applances, clothes or toys;
- **Ubiquitous communication:** Objects are enabled to communicate with each other and with the user, namely through wireless networks;
- **Intelligent user interfaces:** The inhabitant of the AmI space is able to control and interact with the environment in a natural way (e.g., vocally, with gestures) and in a personalized way (e.g., according to preferences, to the context);

The illustration in Figure 1, depicting the interaction of intelligent devices among themselves and with their owner, illustrates one of the key aspects of the Ambient Intelligence concept.

AmI Technologies

It is possible to speak of "AmI technologies" as a new set of technologies. What happens is that resources belonging to different branches of science are taken and used in new applications where they become integrated, made invisible and enabled in order to generate communication paths for "any-to-any" interactions. The nonexhaustive list that follows may give an idea of how much specialist knowledge and how many skills should be called out when speaking of AmI. In this variety, some items would fall under the ICT categories (e.g., languages, middleware, ip-networking, etc.), others under electronics (e.g., sensors, smart materials, nanodevices, etc.). Table 1 presents an approximate classification based on the time of appearance: there are several new and emerging developments, but many advances in the AmI direction also exists in the established fields.

Key Application Domains

The AmI concept applies in many overlapping contexts, and therefore the identification of application areas is unfortunately arbitrary, though necessary if we whish to represent the great fervor pervading this field. We present below a certain number of domains, chosen because of their high rate of development and strong leverage of collective knowledge. We also take into account the results the SWAMI Project (Friedewald et al., 2008), which segments the AmI global field according to safety requirements. An in-depth presentation and discussion of application domains can be found in a book that deals extensively with the whole subject of ambient intelligence (Sorrentino & Paganelli, 2006).

Table 1.

AmI technologies	
Established	Web languages (XML and derivatives) Middleware & servers AI techniques Augmented Reality Linguistic technologies IP-based mobile and wireless networking
Recent	Authoring systems for multimedia content Search engines Machine learning Multimodal Interfaces Speech technologies Context-awareness technologies Sensor miniaturization Self-healing software
Emerging	Location Sensing technologies Presence Management technologies Smart materials Advanced indexing techniques Micro- & nano-electronics High-bandwidth wireless networking

- **Knowledge (includes education, learning, cultural heritage, …)**
  This area is very rich of AmI applications. In the domain of learning, a transition is taking place from technology-based learning (or e-learning) to *ambient learning*, that is, where the supporting system takes advantage of the location and context of the learner, dynamically reacts to his/her necessities, provides information in a flexible and timely way, thus implementing what is called a "knowledge space". The modelling of knowledge spaces is at its beginning, whether we look at physical or virtual spaces. There are, however, already some remarkable implementations: for instance, the interconnected and navigable Web space for "knowledge discovery" built by the Netzspannung organization (http://netzspannung.org) and the experiments in cultural spaces of the MARS group at the Fraunhofer Institute in Germany (Strauss, Fleischmann, Denziger, Wolf, & Li, 2005).
  In the cultural heritage area, the "museum visit" is a popular scenario which has been implemented in several advanced ways. In a case of excellence reported by Cordis/IST, a set of AmI technologies automatically provides to the mobile visitor located in front of a work of art and equipped with a palm device or similar equipment, all the information and knowledge sources that can be wished for (IST, 2005).
- **Work.**
  Here the key vision is that of the "smart workplace", that is, an indoor or outdoor place that enables the individual to communicate and collaborate with distant colleagues, to seamlessly access personal and corporate archives, to be assisted in managing time and travels and to be put in touch with home or family at any time. To satisfy these requirements a heavy use is made of:

  - Intelligent "cognitive" agents, that is, software agents equipped to extract meaning either from static or real-time information;
  - Presence management techniques, to facilitate the organization of meetings and brainstorms;

- o Information visualization techniques, for example, wall displays, interactive surfaces, indispensable tools when the information to be processed is complex and multidimensional.

An advanced implementation in this area is represented by the *SSWs*, the *Socially Supportive Workspaces* of the CHIL Project (CHIL, 2006). The integration of information streams flowing between outdoor and indoor work activities is well implemented by another project, which adopts very clever technologies, the WorkSPACE project (WorkSPACE, 2004).

- **Mobility.**
To be "on-the-move", but simultaneously and permanently connected with the rest of the world, is "ubiquity", a mirage that man is pursuing since ever. AmI comes near to it with applications able to track users with GPS devices on a geographical scale or with RFID tags on a local scale. With such means the user can move freely, surrounded, as it were, by an invisible "information sphere" that follows him everywhere (also called a "digital aura", see Aura Project, 2000). In relation to the e-learning theme a vigorous new stream of applications is developing, based on wireless communications and portable devices, called *m-learning* or mobile learning (mLearn, 2006).
- **Home.**
Even though the "smart home" utopia is lasting since the time of the Industrial Revolution, only recently a branch of industry (sometimes called "Domotics") is providing really practicable solutions. In a "smart" space one of the most important problems entrusted to the systems' intelligence is maintaining the delicate balance between the ability of the user to retain control of the environment and the initiatives of the automation devices. Huge investments in research, industrial prototypes and production are made in this area, see for instance *House-n*, an amazing MIT project (http://architecture.mit.edu/house_n) and *HomeLab*, Philips' lived-in intelligent home (Homelab, 2003).
- **E-Health and E-Care.**
The AmI applications in these two areas (where the «e-» in the term indicates the presence of large ICT deployments) are numerous and very diverse, spanning from the clinical and diagnostics sector to the "wellness/wellbeing" sector. To characterize it, we can choose the applications that adopt, within the variety of AmI approaches, the one called "wearable computing". Wearable computing is a kind of "intelligence" that is "worn on the body" and relies on microprocessors, sophisticated sensors and "body area networks" (e.g., those based on Bluetooth communications). The development of biomedicine and miniaturized sensors has made possible applications that can uninterruptedly monitor our body's vital functions without the inconvenience of wires or the need of specialized rooms. A typical solution is the "Biomedical T-shirt" (MSWebcare, 2006).
A new frontier for AmI in e-Health is the field of clinical psychology, a research stream due to an Italian Scientist, Giuseppe Riva of Istituto Auxologico Italiano. At the basis of his approach, called "cybertherapy", there is the immersion of the patient into synthetical environments and the concurrent use of Virtual Reality, Augmented Reality and Telemedicine (Riva, Davide, & Ijsselsteijn, 2005).

While those presented earlier are vertical views of AmI, it is important to note that there exists a transversal approach to applications, sponsored by a major ongoing European initiative. In 2003, the European Commission launched what is called a "Specific Support Action", with the name of "MOSAIC – AmI@Work Communities". The objective of MOSAIC is the creation of "Mobile Worker Support Environments" on an industrial scale. The key areas being addressed are Healthcare and Wellbeing; the building, construction and manufacturing sectors where concurrent engineering can take place and Rural and Regional Work Environments. Simultaneously, MOSAIC is managing, by means of three distinctive Communities, the development of three "horizontal" strategic areas, named *collaboration*, *mobility* and *knowledge*. The structure of MOSAIC itself is one of the most advanced examples of knowledge spaces, offering on its site a sophisticated repertoire of tools for Knowledge Management and virtual cooperation across borders and over distance (MOSAIC, 2006).

STATE-OF-THE-ART AND OUTLOOK ON THE FUTURE

If the European paradigm for AmI is the “ambient society”, the one of North America is “the Internet of things” and the one of Japan is the “ubiquitous network society”. We observe different AmI “genres” and drivers, though there is a common baseline across the world. In North America, where AmI is driven by the large Federal institutions (e.g., NSF) and Defence Agencies and where extensive research is located in the leading Universities, the focus is especially on software and micro-nanoelectronics for embedded connectivity. In Japan, the leading force behind AmI is the telecommunications industry, which is set out to radically exploit the countless opportunities of wireless networking and the buying power of all its “technological” citizens.

All nations see AmI as a lever of progress but are, at the same time, aware of a “dark side”: the risks related to *safety* (encompassing security, privacy, identity, trust, etc.). The pervasive forms of ICT implied by the deployment of AmI applications put at the forefront the threats to the private sphere of the individual. The “virtual identity” of an individual, an envelope of sensitive information, becomes known to many “invisible” systems (Maghiros, 2006). Insufficient development of safety solutions can be a real hindrance for AmI. However, since the challenge is taken not only by research and industry, but also by the top policy-makers at the Government level—as in (SWAMI, 2006)—we may be comforted that the rush for innovation will not deprive these issues of the investments they require.

CONCLUSION

AmI, though in different forms, is a powerful, shared, worldwide vision. However, on a worldwide scale, its presence and benefits are still allotted only to an élite in the developed countries, and ease-of-use and user adoption remain permanent issues.

The years after 2010—the current horizon for AmI forecasts—will exhibit a much higher rate of technological progress than in the previous decade, with the end effect of driving costs down and therefore favoring user adoption. Looking into the future, Europeans see the “convergence” of technologies as a key event with far-reaching, perhaps unpredictable outcomes (wiring the human being?). The American view is that much change will come from the so-called NBIC sciences—Nano-Bio-Info-Cogno sciences.

We believe that knowledge and learning will be profoundly affected, but we do not see any doom. The innovation injected by new technologies will slowly blend into the fundamental dimensions of existence and improve human life.

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KEY TERMS

Affordance: In a simplified way, it is a concept related to the properties of an object, where the object itself, because of its shape and design, suggests or "authorizes" the way it should be used. The interpretation of affordance, however, is not univocal and depends on the school of thought to which one makes reference. Since its introduction by the scholar J. J. Gibson, a major variation to the set of notions surrounding this concept is due to D. Norman (see before), who discussed it in the framework of industrial design and Human Computer Interaction.

HCI: Human computer interface or human computer interaction. Usually names a field of science that investigates all the aspects of the immaterial boundary in space that exists between a human user/actor and a device with some computing power, not necessarily a conventional computer. HCI is focusing more and more on the interface with handheld devices and more generally on interfaces involving all our senses and mind (not only visual interfaces, but auditory, tactile, perceptual, etc.).

Knowledge Society: In an evolutionary view, it can be seen as the successor of a previous phase, the “information society” (IS), which in turn followed the “industrial society”. IS was so called because of the huge flow of information that was triggered by the advent of computers, data processing systems and communications. In the knowledge society, knowledge, and not mere information, is the most valuable asset. It is what is in the head of people (tacit knowledge) and what can materialize tangibly in the physical world, as print, or human exchanges (explicit knowledge). It is what drives the economy in the new millennium.

M-Learning: Means “mobile learning” and it refers to an increasingly adopted approach to learning that assumes the learner to be distant and mobile with respect to the teaching source and its resources. The supporting technologies comprise wireless communications and handheld, portable devices. The issues and challenges of m-learning are quite different from conventional e-learning, because of the special profile and requirements of the mobile user and his devices (interruptible connections, small screen estate, backward input facilities, etc.).

RFID (also in RFID *tag*): Stands for radio frequency identification. It is the core technology of devices (tags) of very small size that can be stuck onto any kind of object and can transmit data to an RFID receiver located in the same area. RFID is estimated to be one of the most powerful technologies for the development of AmI, notwithstanding its potential risks related to privacy and security.

Usability: Usability is a fine and complex concept, quite beyond intuition. In simple terms, usability refers to the qualities of an object related to its use or, rather, it’s “ease-of-use”. Usability is also the science that studies the principles and design rules to be adopted in order to make usable things. Usability is notoriously a critical issue when dealing with the user interfaces of consumer electronics, computers, communication tools and the Web.

Applying Constructivist Self-Regulating Learning Approach for ICT Students

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INTRODUCTION

Universities face the challenge to ensure that quality teaching meets the needs of the students and satisfies their learning requirements (Beller & Ehud, 1998). Day (1999) suggests that teachers should instill the concept of lifelong learning into their students and the best way to do this is to have commitment to and enthusiasm for this concept themselves.

To this end, it is important to understand students learning process and outcomes. In this article the constructivist self-regulating learning approach is recommended by the authors for higher education—especially for post-graduate students because it is a more realistic reflection of how work and research is done in the real world. On the other hand, the students' learning style and problem solving process are important to their learning outcomes. This research aims to understand the relationships between constructivist self-regulating learning approach to problem solving and student learning outcomes.

The overall objective of this research is to investigate the constructivist self-regulating learning approach in relation to student learning outcomes. In particular, we would like to address the following research question:

What are the impacts of the constructivist self-regulating learning approach to learning outcome(s)?

In this article, we use the interview method to examine the approach for advanced level ICT students in an Australian public university. The first section covers the literature and theories associated with the topic. The second section discusses the methodology for conducting the research. The third section describes findings and results. The article concludes with discussions, implications and recommendations.

BACKGROUND

Constructivist Learning

Constructivist learning has some basis in cognitive learning and is the result of the mental construction of a situation. Constructivism, in its most basic form, is piecing together new information using information already known to the student.

Learning models have historically been based on the metaphor of acquisition whilst recent models have introduced participation as the metaphorical basis (Sfard, 1998). The constructivist standpoint is that students have their own opinions and views and will derive their own understanding from a situation. Central to the constructivist methodology, are three principles (Milne & Taylor, 1995, p. 40):

1. Learning involves mental construction of knowledge by individuals, rather than absorption from external sources;
2. The "concept of absolute truth" is replaced with the "concept of viability"; and
3. Knowledge construction is a social and cultural process mediated by language.

According to Tetard and Patokrorpi (2005), the constructivist learning environment is associated with the following aspects:

- Organize a small assessment task to achieve overall learning objectives
- Ownership of learning and problem solving
- Task must closely relate to real life problems
- Allows different aspects or solutions to solve the assessment task/problem

- The learning environment should be very similar to real life environment
- Allows interactive learning
- Guidance should be provided
- Building on the students' prior knowledge
- Opportunity for social interaction
- Communication with peers and others
- Allows alternative learning strategies

The constructivist methodology encourages a teaching and learning approach that gives the students the opportunity to participate in a learning community where the instructor is not the only source of information and knowledge (Bruce, Weil, & Calhoun, 2004). Technology is introduced as a tool that supports the learning process as students seek knowledge and understanding.

Constructive Self-Regulating Learning

The constructivist pedagogy according to Howe and Berv (2000) incorporates two factors, the first being that teaching must start with the knowledge, attitudes, and interests of the student in mind. The second is that the teaching must be designed to allow students, through their own experience, to interact with the material in order to *construct* their own understanding. Other definitions of constructivism are described by Poplin (1998) as "[the] process whereby new meanings are created by the learner within the context of her or his current knowledge". Zimmerman and Schunk (2001) provide seven theoretical views on self-regulated learning, each of which have their own concepts on "key processes, environmental conditions and acquired capacities." These different views are directly quoted from Tillema and Kremer-Hayon (2002):

- **Operant:** Stressing self instruction, modeling and shaping of behaviour; emphasizing provision of relevant stimuli for learning
- **Phenomenological:** Stressing self-worth, subjective experiences, and development of a self-system emphasizing personal identity
- **Information processing:** Stressing transformation of information, and self-monitoring with relatively little attention to environmental conditions
- **Social cognitive:** Stressing self-observation and enactive experiences, through social learning: emphasizing self-efficacy in learning
- **Volitional:** Stressing controlled actions to regulate emotions and environmental conditions.
- **Vygotskian:** Stressing inner speech, dialogue, and mediation acquired through a hierarchy of developmental levels.
- **Constructivist:** Stressing personal theories, discovery learning, and development of self-regulatory processes based on conceptual change.

Athanasou (1999) also indicates that there are several different theories of self-regulation. He, like Zimmerman and Schunk (2001) has broken these theories into different views. In his case three views, the operant or behaviorist which stresses the links between the environment and its reinforcers, the phenomenological or humanist which stresses the self and self-regulation and the social-cognitive models which attempt to bring the two previously stated theories together as well as stressing the cognitive aspects. Paris and Byrnes (1989) describe the constructivist approach to self-regulated learning by first describing the principles of a cognitive constructivist approach. They divide it into *six principles* of learning whereby people have:

1. An intrinsic motivation to seek information
2. A desire to develop an understanding that goes beyond the information given
3. Mental representations that change with a person's development
4. Levels of understanding that are progressively refined at time goes by
5. Developmental constraints on learning
6. Reflect and reconstruct to stimulate learning

These authors further suggest that the notion of theory does provide a framework for self-regulated learning and that this notion includes aspects such as formulating and testing hypotheses, acquiring new data, and solving problems.

Moon (1999) describes the constructivist view of learning as emphasizing the teachers role as a facilitator of learning and that the learner constructs the learner's own knowledge in a network fashion, much like "building bricks in a wall." Moon (1999, p.106) describes the approach as "[stressing] the content and organization of the curriculum as being the basis for learning and implies that knowledge is built from ideas that the learner gradually assembles." The constructivist approach stresses that the learner becomes more engaged in meaningful learning and that the learner desires to understand the material rather than simply memorizing it (Moon, 1999). This description of the constructivist approach is closely aligned with the desired approach for course development outlined in this article.

This literature suggests that the constructivist approach to self-regulated learning involves allowing students to develop their own theories and through a series of cycles of reflection and reconstruction to develop a solution. This interpretation is similar to the definition of the self-regulating learning approach by (Zimmerman & Schunk, p. 5) as "the degree that students are meta-cognitively, motivationally and behaviorally active participants in their own learning process." The different views of the self-regulated learning theory are brought to the attention of the reader as background information. Whilst they are of concern for this study, we wish to concentrate mainly on the practical application and how an understanding of the basic underlying theory of self-regulation can help students with ICT courses. The next section of this article stresses the practical application of the approach.

The constructivist approach as advocated in this article has been established as a useful aid for many strategic initiatives that involve business applications, for example (Chermack & Van Der Merwe, 2003) describe the role of constructivist learning in scenario planning. (Chermack & Van Der Merwe, 2003, p.446) consider that the four critical components of a constructivist learning perspective as being "the individual construction of knowledge, social influences on individual constructions, the situatedness and contextual requirements of knowledge construction and the social construction of reality". These components are considered to be key enablers to the desired goal of changing the mental models of participants in scenario planning.

This research looks at using the constructivist approach to two courses in ICT in a business school in Australia. The constructivist approach was used to inform the development of assessment items in both courses. Student opinions on the approach were obtained through interview.

METHODOLOGY

The research consisted of two components; the first was an in depth interviews of eight students involved in an ICT course (information management and control) at the postgraduate level.

Interviews Used to Evaluate the ICT Course

The research method used in first component of this research is the interview approach (Yin, 1995). One of the key advantages of interview is that it balances a purely quantitative method by allowing for integration of researchers' and practitioners' perspectives in a cost-effective way (Creswell, 1994; Kraemer, 1991; Marriam, 1988; Morgan, 1998). Another advantage of interviews is that it collects information without losing any significant details (Frey & Fontana, 1993; Fink, 1995; Crabtree et al., 1993; Light, 1971). As well, an interview is extremely important in capturing rich information and to develop and confirm the context for the theoretical model (Ericsson & Lehmann, 1996; Malhotra et al., 1996; Marriam, 1988; Zikmund, 2000).

In this research, several strategies were used to ensure the interviews were successful. An experienced interviewer was employed and this enabled a high reliability to be attained. Detailed notes were taken during the interviews and tape recordings and transcripts of each interview were made.

The convergence and divergence in each issue was raised, enabling the constructs of interest to evolve throughout the interview process. The process required openness to new ideas as well as ensuring that all factors were captured (Frey & Fontana, 1993). The data collection provided information useful for generating or confirming the theoretical model under question (Hammersley, 1992; Neuman, 2000). Details of the methodology will be discussed in the following sections.

The communication channel was face-to-face (FtF) semistructured interviews. The questions design for the interview was focused on open-ended questions (Crabtree, Yanoshi, Miller & O'Connor, 1993; Fink, 1995; Frey & Fontana, 1993). Three independent reviewers assessed the questionnaire before the interviews. The interviews were approximately 30 minutes each, and they were tape-recorded and transcribed. Interview question design was based on the Paris and Byrnes's (1989) six principles. Appendix 1 shows a copy of the interview questions. The analysis of the interviews' transcripts followed Miles and Huberman's (1984) recommendation—a coding scheme based on the theoretical framework was developed, and the transcripts were coded based on the scheme. Overall, the study aimed to focus on the constructivist self-regulatory learning approach in learning outcomes.

ASSESSMENTS WITHIN BOTH COURSES THAT REFLECTED THE CONSTRUCTIVIST APPROACH

Assessment items developed to be consistent with the constructivist approach in both information management and control course was used and evaluated. These assessment items are shown in the next section.

Assessment Task

The assessment task was designed and formulated from Tetard and Patokorpi (2005) suggestions. Table 1 provides information about the learning environment and the assessment task. The assessment was a research assignment. Students were given seven weeks to complete the task. Students were required to complete the following tasks:

1. Choose a topic within the information management and control subject area,
2. Conduct research (state-of-art and state-of-practice)
3. Identified problems or issues from the literature review
4. Provide case study or solutions to the problems that were identified
5. Discuss and provide personal opinions/views to the cases and/or solutions.

In this assessment task, students could work either in a group or individually. Three tutorials (one hour each) were allocated to provide each group or individual feedback before the submission due date. Consultations were also available outside teaching hours for those students who needed additional help for their assignments. E-mail and discussions board facilities were made available to support communications between students and the lecturer. The final results and written feedback were given to the students after the completion of assessment/assignment.

FINDINGS

The interviews for the first component of this research were conducted at a public university in Australia between October and November 2005. Six students (one female and five male students) were randomly selected and asked if they would do the interviews. All selected students volunteered to do the interviews. The students were all operating at the postgraduate level in the ICT major. Ages ranged from 20 to 39 years old. Half of the interviewed students were international students with less than two years living in Australia and the other three were local students. Four students were working or had industry working experience in IT or related areas. Table 2 summaries the student attributes.

The Interviews

As a warm-up, students were asked about their study progress in general. Upon completion of the warm-up, a serious discussion of the main study was begun. The following descriptions related to the constructivist learning approach and were used throughout the interviews. Results are classified into five levels, namely:

1. Motivation
2. Desire to develop an understanding
3. Mental representations
4. Level of understanding
5. Reflection and reconstruction.

The following sections provide student responses to the five levels shown above.

Motivation

Students indicated that the intrinsic motivation to seek information was of a personal interest to them. The extrinsic motivation was good marks, commitment to group members, appeasing the lecturer and the development of practical and useful skills for future employment.

S1. “For the assignment, I have selected a topic which I’m very much interested in, i.e., ERP as Enterprise Integration. First, topic is about current business trends and current technology that specifically increase my interest in seeking more and valuable information about that, it also increases my knowledge about that topic too. As I’m an IT person it is important for me to go with current trends this is also one of the reason that motivates me to seek more information.”

S2 “The basic motivational source for me is discussions, with my group mates and the preparation

Table 1. Learning environment and assessment task

Learning design	Assessment task
Organize a small assessment task to achieve overall learning objective	The assessment is designed to test the student's understanding of the different aspects of information management and control. Students choose of the following topics, conducted research, provided discussions and suggested solutions/ personal opinions 1. Describe the importance of information management and control. 2. Identify the various levels and aspects of information management and control and explain how they affect both IS users and IS professionals. 3. Explain and apply application and access controls and data protection. 4. Develop skills in critically evaluating various security and control strategies and tools. 5. Explain what project controls are and their importance to organizations. 6. Explain the processes involved in evaluation, and undertaking of IS audits. 7. Appreciate the current concerns of IS users and professionals regarding information management and control and be able to develop and implement the strategies designed to address these issues.
Ownership of learning and problem solving	Students undertake ownership of their learning in order to conduct research in areas of Information Management and Control.
Task must closely related to real life problems	The Assignments have been designed to develop the student's ability to critically review literature, evaluate a real-world scenario, undertake research into possible solutions, then select the solution that provides the best fit for the organization and justify the decision. The assignments are designed to provide students with practical skills as well as an understanding of the information management and control issues that are relevant regardless of their chosen career path.
Allow different approaches to solve the problem	Students free to provide personal opinions and solutions to the problems that are identified.
The learning environment should be very similar to real life	Students are required to choose a topic, conduct research (state-of-practice and state-of-art), evaluate a real-world scenario and provide opinions and solutions to the problems identified.
Allows interactive learning	During the learning process, students can discuss areas of concern with their group members. They can post their questions and comments via the discussion broad and the interactive course website.
Guidance should be provided	An overview of the assessment task is given during the lecture. Feedback and consultation times are available to guide the student through the learning process.
Building on the students' prior knowledge	The course is an advanced subject in ICT. Students are furthering their knowledge in ICT. Further, they are encouraged to choose one of the given topics which they are interested in and have prior knowledge of.
Opportunity for social interaction	Students can meet and discuss their assignments during the allocated tutorial times and outside the teaching hours.
Communication with peers	Three tutorials (one hour each) are allocated for students' discussions. E-mail and discussion board facilities are also available for students
Allows alternatives of learning strategies	An option was given that allowed students to work in groups or as individuals. This was designed to suit their learning strategies. For instance, some students preferred working individually where as others prefer working in groups.

of the basic rough sketch of the assignment. We then ask the questions. What do we have to do? Who will do what? Once every thing is discussed it gets down to black & white issues. Second source is lecture time discussions, and the feed back given by the lecturer helps me make changes from my original design. Last but not the least is the one-to-one discussion with the lecturer."

S3. "Initially, the main motivation for seeking information was to ensure that I score well in the assignments. But as I kept on searching for information, I found some topics interesting and so I was looking for extra information than needed for the assignment. As I went in to more details, I came to realize from the practical point of view, i.e., from a business perspective how useful the information was. So, eventually

Table 2. Demographic attributes of students in the first component of the research

	S 1	**S 2**	**S 3**	**S 4**	**S 5**	**S 6**
Major	IS	IS	IS	IS	IS	IS
Full time (FT) / part time (PT) students	FT	FT	FT	FT	PT	PT
Age group	20-29	20-29	20-29	20-29	30-39	30-39
Local/ International students	International	International	International	International	Local	Local
IT Working Experience	No	No	Yes	Yes	Yes	Yes
Gender	Male	Male	Male	Male	Female	Male

you could say that the main motivation for me was the practicality and usefulness of the information after I graduate and enter my professional life."

S4. "I get the motivation to study Information Management and Control as an IT student it is a part of my interest and passion. The only thing constant in this world is change and the punch line of today's era is 'INFORMATION RULES' and so it becomes all the more important to seek information and to secure it."

S5. "I generally like to learn new things, I like to challenge myself. I think I am also very reflective so I like to look for better ways of doing things and this drives me to find out information. I like to do well and I don't particularly feel comfortable when I don't understand something thoroughly so I tend to want to find out more until I understand it sufficiently to feel comfortable."

S6. "For the assignment we found a subject that was interesting then looked further and further into it to understand what was actually happening and then made an assessment about where things could be improved. Part of the motivation was that there was an assignment to do and I wanted to do well, why, because I don't really know how to do anything less, I found working with a motivated partner an incentive to research more and communicate that research in greater detail than I would have done alone."

Desire to Develop an Understanding

The majority of students tend to have a desire to develop an understanding that goes beyond the information given. One student (S2) had a different view on this but still had a desire to want to work in a real world problem-solving environment.

S1. "Yes, I am [interested in understanding beyond the information given]. As it is not at all a good idea to limit ourself with this infinite world of information. And the topic, I have chosen is not going stop me developing more advance ideas."

S2. "I rather to be given a assignment which is real life case, because that helps students to develop their skill according to real life and real world. The case should be more realistic, so that we can write from our own experience, based on what we learnt in the course."

S3. "Yes, mainly because to have proper understanding of the subject which will help me to score highly in the assignment. Secondly and more importantly is the application and implementation in the business world."

S4. "While researching about a particular topic especially secured servers, monitoring, interceptions, active directory, a lot of times I sit on the computer for hours and go beyond my topic of assignment."

S5. “It depends on the information I tend to glaze over when the information is too technical and really have to force myself to understand what I needed to know.”

S6. “if a subject catches my interest it seems only natural to want to learn and investigate more about it. Did I have the desire to learn more and develop a deeper understanding? Absolutely and always.”

Mental Representations in Self-Development

Most students have mental representations that change with self-development. Students indicate that their thoughts on their own self-development include factors such as: increased knowledge in the field, understanding of current trends, increase in self-confidence, and getting new ideas, improved skills from group members, ability of work collaboratively, technical skills in writing an academic report, and being able to apply skills in other assignment task. However, it appears that one student did not put enough effort on the assignment and there was no indication of self-development in mental representations.

S1. “It’s very helpful in myself-development as it helps me increase my knowledge about new ideas. It also helps me go with current trends, moreover it helps in increasing self confidence for getting new ideas.”

S2. “to be honest, I haven’t given my 100% for this assignment, [the reason behind is it was very vague].”

S3. “Firstly , working as part of the group has taught me that the sum of all parts is greater than the whole . Even though my group member and we have our own set of individual skills, when we worked together we were able to compensate for each others weakness and in the process the final result was much better than if we had done it individually.”

S4. “I personally feel that the level of research I did was satisfactory for the assignment. I see my self gaining more knowledge about the field and look forward to feedback for improvement as well.”

S5. “It was the first for me in a number of ways it was much more open and research focused than I had done previously and I enjoyed this, and it was also the first essay type assignment I had done in a group and this was good self-development for my ability to work collaboratively.”

S6. “The basic technical skills of writing an academic report and understanding more about academic research have been most interesting lessons. The opportunity to find a very specific problem then search and develop a potential solution has left me far more enthusiastic about academic study than before and the general increase in understanding of the world around me is satisfying. The experience of academic research has been such that I am keen to do more, and have begun my own research into other areas branching out from the assignment task.”

Levels of Understanding

It was unclear whether all students have a level of understanding that was progressively refined as time goes by. Some students seem to have developed some incremental understanding (particularly S1, S3, S5, and S6).

S1. “Before doing the assignment, we had little understanding about our ideas. As we have got more Information and read the new ideas coming up, it helped us a lot in understanding the current business and IT world.”

S2. “.. to work for all of assignments (for all subjects) I am unable to give the best of my knowledge.”

S3. “The research done for the assignment in additional to the weekly tutorials and the lectures give much information about the subject from different perspectives. Like we get the lecturer’s viewpoint on a topic in the lecture, where as in the tutorials we get other people’s viewpoint on the topic during their presentation. And finally our own research and understanding of the topics.”

S4. “In case of information management and control, the learning part depends more on the individual interest rather than what is taught. If you have interest in a particular field then you would definitely like to excel in that.”

S5. "Initially we decided to work together as a group and then looked for a topic we both wanted to work on and we seemed to find this in biometrics as it had enough different aspects to interest both of us. We were looking at a much higher level and then as we researched more we began to identify some consistent issues and to see patterns within the research. Those patterns were a combination of what wasn't talked about as much as what was. We selected one of these for our topic."

S6. "Personally I find that understanding tends to be achieved in steps rather than a progressive spectrum. There is knowledge given about a subject and I can use and implement that knowledge without really understanding it, but one day there comes a point where as if out of the blue it all makes sense and I move to a deeper level of understanding. One of the things I appreciated about learning some research skills (academic research) was that it made the steps and time between knowledge and understanding a shorter process."

Constraints on Learning

The common constraint was time. Other constraints were gathering information from different sources, working in a group, learning technical concepts, referencing and assignment templates, the library system and a lack of awareness of the academic research process also impacted on student learning.

S1. "Its very hard to find but I think We are knowing the facts by getting the information from different sources."

S2. "..Web based and journal based searches for the material gets more importance rather then the knowledge of the student, Mostly students are considered dumb but in reality they are not. They should be given more liberty to express their own views and ideas….
Students get worried because they will be having all the submission due almost at the same time or may be in the same week. It is not valid to give assignment way before the submission date but they should be given in a planed manner so students will not be under pressure, and over stress themselves"

S3. "the topic was so vast the main constraint was to focus our teams' attention and energy on one aspect and research that in detail. Apart from that, sticking to the preset template and strict following of the anti-plagiarism policy by which I mean making sure all quotes or citations are included along with proper referencing."

S4. "The constraint in my learning process was my group member as initially we were not able to decide the topic and later on I was the only who did the majority of work as my group member had other assignments."

S5. "For me time was a constraint, I have to juggle a lot of different demands, work, family and study and make trade-offs between them, I think this semester I had taken on too much work wise and so had to trade off study wise which disappointed me. Also I know I struggle with technical detail, my mind goes blank when I see the word algorithm or some of those diagrams and I really have to force myself to reread them, because of this I tend to avoid topics where I have to deal to extensively with them… I was a bit disappointed in that I would have enjoyed spending more time on it but I was really pressured in other aspects of my life i.e. work that I didn't have enough energy or focus to apply as I would have liked."

S6. "Time, if there were more hours in the day and less need for sleep I could learn more. Part of that time constraint is the time it takes to find relevant information. The changes in the library systems were a great hindrance in the assignment process as all searching other than in the library catalogues had to be done from a computer lab or home.. Lack of awareness of the process of academic research led to wasting time and effort looking in some of the wrong places also."

Reflect and Reconstruct

It seems most of the students' demonstrated reflective thinking or reconstructed their learning experience into their future plan. Only S2 believed that the practical working experience is the most valuable to his future success.

S1. "In the future I have decided to expand my knowledge for this topic and for that I have planned to have real world experience in an organization and include it in my University learning too."

S2. "In my life I have learned most of the things with practical experience which is the key factor of my success so far. I have done two Masters and will be joining soon a world renowned company for my job which proves that my way of learning is better and will definitely bring success and glory."

S3. "I realized the practical use of the assignment topic and how essential it is for businesses. This made me realize that an issue of such eminence should not be taken lightly and it is better to gain as much knowledge about it as possible. Hopefully, due to this assignment in future I would be better prepared to tackle these issues if I ever face them."

S4. "Personal feedback along with discussion about my personal goals would definitely help me to improve my learning outcomes. I would be obliged if you (lecturer) could shower some pearls of wisdom as this will be a great impact. I have always wanted to carve a niche for myself and tutelage of such a great academician would be really appreciated."

S5. "I think in the future I would be more cautious in how much I take on. I think I have also decided that you can't be good at everything so unless it is a core course or really necessary. I am going to focus on what I enjoy because it just makes it so much easier and enjoyable. I also think in working with someone else I tended to see things differently and it was easier to go into areas I wouldn't go on my own. So if the opportunity to work with someone else came up I would try it again. I still don't like the uni take on group work overall but I liked the idea of being able to work in a group if you wanted and could say no if you didn't and would probably be more likely to do an assignment of this nature in a group again."

S6. "A more detailed knowledge of the process allows the time it takes to gather information and put a document together to be reduced. Also understanding that much of the information is available on-line means that only book references require trips to the university library. The knowledge of how and what to prepare for a task has reduced the time it takes me to find relevant information considerably."

Summary of Results

Typically, international students often have writing problems. If English is their second language, there is a need to improve the teaching program and this needs be considered to assist international students. One student (S2) had no intrinsic motivation, had no desire to understand the assessment task, preferred do something else, did not put enough effort in the assessment task and did not believe in the university learning system. The student received the lowest score in the assessments task among the interviewed students. Feedback from the assessor for S2 indicated that the student's assignment was—a *little bit too broad, poor quality materials used, some sections were too brief, the student needed to improve his/her writing style, references and structure.*

The majority of students demonstrated a desire to develop an understanding if they were interested in the assessment task. For example:

S2. "I rather to be given a assignment which is real life case based. The basic motivational source is discussion, with the group mates …"

All other students indicated a desire to develop an understanding of the topic. For example,

S4. "While researching … it happens a lot of times that I sit on the computer for hours and go beyond my topic of assignment"

S6. "if a subject catches my interest it seems only natural to want to learn and investigate more about it."

Only one student showed little interest in self-development. The student suggested that:

S2. "I haven't given my 100% for this assignment"

Students who were motivated only by others, with no desire to develop an understanding did not put effort into the assessment task. The results indicate that this student is unlikely to score well in his/her assessment task for example S2 had the lowest mark among all interviewed students.

Table 3. Summary of the results of the interviews

	S1	S2	S3	S4	S5	S6
Motivation	Interest and current trend	Group members	Marks and practical and useful for future employment	Interest and passion	Learn new things and challenge	Interesting, do well and group member
Desire To Develop An Understanding	Yes, development more ideas	No, rather to be given something else in the assignment	Yes, proper understanding and implication to the business	Yes, spent lots of time and beyond the topic	Depends information, Forces to understand things need to be learned and known	Yes, catching interesting things
Mental Representations In Self-Development	Increase knowledge when new idea comes, improve self confidence	Not given 100%, reason is very vague	Compensate for each others members weakness and skills	Gaining knowledge about the field	First learn in research, self development in collaboration	Basic technical skills in academic report
Levels Of Understanding	Lots understanding of current business and IT world	busy with all other assignments, unable to give the best	information from different perspectives	Self interests are more important	From high level to details	Research skills
Constraints On Learning	Gathering information from various sources	Prefer do something else, not allowed to express own knowledge and time	Focus team attention, use of template, references	Group member collaboration	Time and technical details	Find relevant information, changes of library system, lack of awareness of academic research process
Reflect And Reconstruct	Aim to get working experience in this area	No, only from own working experience	Realization - take work more seriously and gain more knowledge	Would like to get personal feedback on this assignment from lecturer	Cautiously how much can take, choose subjects are based on enjoyment, and group work	Better time management – information gathering and understanding academic research process
Assessment results	82%	59%	74%	68%	86%	86%
Assessor comments	good use of sources, well structured, interesting topic	Not focused, too broad, quality of materials used, some sections are too brief, improve writing style, references quality, structure of the assignment	Interesting topic, well organized, please improve writing skills	Too much information and not very focused. Please improve writing style and structure of the paper	Excellent, well-written and clear structure. Interesting solutions	Very interesting topic, well-written and clear structure. Interesting suggestions

Looking at the constraints to learning, the main constraints were time, information gathering and group members. In particular, time was a common constraint for most of the students.

S2. "Students get worried always because they will be having all the submission almost at the same time or may be at the same week

S5. … I was a bit disappointed in that I would have enjoyed spending more time on it but I was really pressured in other aspects of my life

S6. Time, if there were more hours in the day and less need for sleep I could learn more.

Another common constraint is information gathering.

S1. "Its very hard to find [the required information].."

S3. "..the topic was so vast the main constraint was to focus our teams' attention"

S6. "..time it takes to find relevant information…"

Almost all students reflected on their learning experience. However, only one student (S2) indicated that the practical working experience was more important to future success.

S2. "In my life I have learned most of the things with practical experience which is the key factor of my so far success….will be joining soon a world renowned company for my job which proves that my way of learning is better and will definitely bring success and glory."

DISCUSSION

One author of this article had developed this approach for ICT education independently over a three year period, however it is acknowledged that the constructivist approach has been recommended for ICT education recently (Tetard & Patokrorpi, 2005) and this article is now expanding on that theme. Therefore the purpose of this article is to apply the approach and to test student acceptance of courses developed.

Constructivist Self-Regulating Learning

The overall results suggest that personal interest is one of the most common factors associated with learning motivation. Other motivation factors such as new and challenging ideas, development of practical and useful skills, future employment opportunities, current employment trends, marks received, and other people are also important to student motivation.

Learning Outcomes

Looking at all individual cases, the findings shows that students who achieved better marks were interested in the assessment task/assignment topic. They captured new, relevant, and interesting information during the learning process. They often enjoyed their learning process. Learning constraints do not seem to be the most critical factor to their learning outcomes. According to assessor feedback of the assessment item in component one of this research, these students have common characteristics—*well written, good structure of the assignment, and interesting solutions.* Students who have good writing skills, creative and innovative ideas are able to excel in their assessment tasks.

Implications

The overall results suggest that the assessment task (research assignment) proved to be positive to teaching and students' learning experience. In particular, students were motivated by the self-selected topic and the flexibility of the assignment. The interview results also indicate that students' learning process such as mental representations and level of understanding were increased. Students were able to identify problems, apply theory to practice as well as provide personal views in the areas of the subject domain. They were also able to reflect and reconstruct their learning experience for future use. The learning outcomes (student marks and assessor comments) also consistently reflected Paris and Byrnes (1989) six principles of constructive self-regulating learning theory. This suggests that positive learning lead to better learning outcomes. When designing an assessment task, it is very important that the assignment problem appeals to the students' interests.

Feedback on progress (before the submission) and group discussions during the tutorials (three tutorials and one hour each), had a positive impact on learning experience and outcomes. This reflective practice (feedback to students) is key element to self-development (Lupton, 2002).

Mayes (2000) has pointed out the need to maximize peer dialogue through group discussions. The group discussions could be between two or three groups who share the same tasks (Hardaway & Scamell, 2003). This also provides good learning atmosphere during the learning process. It is recommended that regular feedback should be provided to ICT students.

On the other hand, time is one the major learning constraints. Students had difficulties in balancing university study, work, and family commitments. For instance, one student complained that the majority of assignments were due at about the same time and this increases students' stress and reduces motivation. In Australia universities, the normal semester runs 13 teaching weeks. Assignments are quite often due in week 7 or week 13. Exam runs in weeks 15-16. In the case of Information Management & Control, the lecturer-in-charge was asked to extend the deadline for two students twice. This suggests that deciding of assignment deadline is important and it should be considered and taken into account when designing an ICT course. On the other hand, such a luxury is not available in a real world work context and students should be aware of this.

In comparison, most people generally believe that their teamwork skills are improved when the groups are heterogeneous. The heterogeneous group refers to group members who have different knowledge and skills sets (e.g., Kanet & Barut, 2003). The case at hand shows that students who had different skills and knowledge are able to enhance the group's performance and results.

On the other hand some teams spent too much time on decisions such as the topic, communication methods, meeting times and locations, the division of labor and delivery timeframes. These students set more strict requirements for prior knowledge and experience of the subject matter (e.g., Dineen, 2002).

Further, poor estimations of the amount of time required for research and gathering relevant information, commitments of other courses' assignments, amount of contributions to the assignment among the group members and poor teamwork meant that some groups became inefficient and ineffective with respect to learning outcomes.

Despite these issues of teamwork, there were no complaints made to the lecturer. This is because that the lecturer-in-charge gave the students an option—either work individually or in a group. Some students saw the teamwork as beneficial whereas others did not. It is recommended that lecturer-in-charge should provide awareness of teamwork and group performance guidelines for students to help them in selecting group members. These guidelines should reflect the benefits for student learning experience and outcomes.

Results cleaned from the reflective diaries of students from the second component of this research indicated two levels with one group of students enjoying the freedom of being able to select their own assignment while the other group (predominately international students) wanted a more prescriptive assessment item.

Recommendations

In summary, the constructivist self-regulating approach has benefits to IS teaching and students learning. To improve IS teaching and student learning, it is recommended that

1. Students should be allowed to choose assignment topics that they are interested in.
2. Regular feedback and checking student's progress is important.
3. The teacher should be a proactive listener and listen to students' learning problems and address these problems.
4. The communication channel should not just be face-to-face. A good use of email and the discussion broad is important. Especially for those students who don't attend classes regularly.
5. Deciding deadlines should take into account other courses when designing a course outline.
6. There needs to be an awareness of teamwork issues and benefits and optional teamwork is recommended.
7. There needs to be guidelines for selecting group members (e.g., working style, students strengths and weakness)
8. Teachers need to manage students' expectations—information such as the requirements for the assignment task should be provided to new students. This could include past student learn-

ing experience on a similar type of assignment, learning process and experience, benefits and common issues such as time management and teamwork.

9. International students concerns about a lack of structure in assessment items need to be addressed, and this can be done by providing clear guidelines and positive reinforcement as each student progresses through the course.

CONCLUSION

The article described the importance of constructivist self-regulating learning approach. The overall aim of this research is to improve ICT teaching and student learning. The findings suggest that a constructivist self-regulating learning approach has positive implications to student learning experiences. A number of recommendations are suggested to improve ICT teaching and student learning experiences and outcomes.

It is expected that this approach would be well accepted by employers, although this was not tested and is an acknowledged limitation of this research. Future research should look at determining the level of acceptance of this approach by employers of future students and the concerns students may have with respect to the nonprescriptive nature of assignments. This appears to be a real concern especially with some students who have concerns about the lack of structure that this approach can appear to give to the course. The authors consider that the approach is worth pursuing because it should result in a graduating student cohort who can independently research and solve problems much in the same manner as their experienced colleagues would do in the real world work environment.

The fact that this approach has been developed independently by academics in both the United States of America and Australia is an indication of the perceived potential of the approach in improving ICT education outcomes.

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KEY TERMS

Constructivist: Stressing personal theories, discovery learning, and development of self-regulatory processes based on conceptual change.

Constructivist Learning: Constructivist learning has some basis in cognitive learning and is the result of the mental construction of a situation. Constructivism, in its most basic form, is piecing together new information using information already known to the student.

Constructivist Self-Regulating Learning: The process whereby new meanings are created by the learner within the context of her or his current knowledge.

Operant: Stressing self instruction, modeling and shaping of behavior; emphasizing provision of relevant stimuli for learning.

Phenomenological: Self-worth, subjective experiences, and development of a self-system emphasising personal identity.

Social Cognitive: Self-observation and enactive experiences, through social learning: emphasising self-efficacy in learning.

Volitional: Controlled actions to regulate emotions and environmental conditions.

Vygotskian: Inner speech, dialogue, and mediation acquired through a hierarchy of developmental levels.

APPENDIX 1. INTERVIEW QUESTIONS

Model	**Questions**
Intrinsic motivation	1. What is your motivation to seek information?
Desire to develop an understanding beyond the information given	2. Did you have a desire to develop an understanding that goes beyond the information given? Why?
Mental representations that change with a person's development	3. How would you describe your self-development from this assignment?
Levels of understanding that are progressively refined at time goes by	4. Please describe the level of understanding are progressively refined at time goes by
Developmental constraints on learning	5. What are constraints in your learning process?
Reflect and reconstruct to stimulate learning	6. How did you construct and reflect this experience in your future learning?
Learning outcomes	7. How would you describe your learning outcomes relative to your learning approach?

B

B2B E-Commerce Development in Syria and Sudan

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INTRODUCTION

There is a revolution transforming the global economy. Web technology is transforming all business activities into information-based. The rate of technological change is so rapid that electronic commerce (*eC*) is already making fundamental changes in the electronic land-escape. *eC* over the Internet is a new way of conducting business. It has the potential to radically alter economic activities and social environment and it has already made a major impact on large sectors such as communications, finance, and retail-trade. *eC* has also been hailed as the promise land for small and medium sized enterprises. Therefore, it will no longer be possible, operationally or strategically, to ignore the information-based virtual value chain for any business. *eC* promises that smaller or larger companies as well as developed or developing countries can exploit the opportunities spawned by *eC* technologies and compete more effectively.

The introduction of the Internet for commercial use in 1991 had created the first real opportunity for electronic markets. It offered a truly global publicly available computer network infrastructure with easy and inexpensive access. After nearly three decades of not-for-profit operations, the network was transformed into a worldwide digital market place practically overnight. This shift from physical market place to a digital one had contributed a great deal to cost reductions, speeding up communication, and provision of users with more timely information (Shaw, Gardner, & Thomas, 1997; Timmers, 1999).

It is, then, clear that *eC* is still a phenomenon that is waiting to happen in any big way. Companies are optimistic about its future impact, as long as issues regarding skills development and technological and managerial constraints of existing systems can be alleviated. These are the conclusions of recent independent pieces of research which largely agree with each other that although the Internet is widely used for finding information, it is still at an early stage in terms of real business benefits and has not started to make its mark on the bottom line through either reduced costs or increased sales as it has been indicated by McLean-Smith (2000).

The Internet is growing so fast to the extent that (although figures may differ in different studies) there were 150 million online users worldwide in 2001 and the number is expected to increase to 500 million by 2005 (Kamel & Hussein, 2001). Among those users are companies, which believe that the Internet is an attractive means to do business and attract customers.

Despite the failure of hundreds of *eC* businesses since the dot-com crash in 2000, companies are still investing and operating in digital economy. A recent study reported in Teo and Ranganathan (2004) expects that global B2B *eC* will reach $2.77 (US) trillion by 2004. The main benefits identified by the research are the reduced costs, mentioned by 57% of the respondents in the study, with 66% crediting their Websites for bringing in new customers.

eC is the use of new information systems such as the Internet to conduct business. *eC* applications include new ways of conducting business between and across organizations (Applegate, Holsapple, Kalakota, Raddemacher, & Whinston, 1996). However, *eC* requires advanced technology, management approaches and informed customers.

This chapter reports on the results of an exploratory study of B2C *eC* development in developing countries drawing on data collected from Syria and Sudan. It investigates the development and use of B2C *eC* applications in Syria and Sudan and reflects upon management approaches, employees' skills level, and problems that hinder *eC* development.

The study concludes with future strategies and directions of B2C eCommerce in the developing countries and suggestions for future research.

BACKGROUND

B2C *eC* applies to any business that sells its products or services to consumers over the Internet. It includes remote (or home) shopping, banking, and stock brokerage, accompanied by (and in some cases, so far paid by) online advertising. The intended audience for this market has not reached a critical mass, although the immense potential of this segment is driving much of the interest in *eC*. B2C marketing is no longer driven by mass marketing but rather by target marketing and interactive dialogues with customers (Bradley & Nolan, 1998; Kowtha & Choon 2001). The opportunities that B2C *eC* promises may be realised in the following broad areas of business activities:

- **Target customers:** Obtaining a target audience through customer information.
- **Buyer values:** Understanding what the customers are really looking for.
- **Customers retention:** The value of customer retention and loyalty (lifetime value of a customer).
- **Customer equity:** Placing the emphasis on customer equity instead of brand equity.
- **Mass customisation:** The ability to customise products on a mass basis, requiring a one-to-one dialogue.

While companies are now required to know more about their customers and work to retain them, there are a number of challenges that make it even more difficult to win in a business to consumer sale. Those challenges are:

- The increasing number of consumers' choices.
- Competition for attracting and retaining customers.
- Consumers' and businesses' access to real-time information requiring faster decision-making.

Also the World Wide Web has changed the marketing/selling experience for businesses and their customers because of a number of unique characteristics, namely:

- Interactivity
- Fast response
- Global reach
- Tailored and targeted information
- Compressed marketing/sales cycle.

On the other hand *eC* is also changing the paradigms for pricing, buying and selling to consumer. New virtual companies like Virtual Vineyards and Amazon.com maintain zero inventories yet they successfully sell to consumers. They assemble a number of service pieces that are required to deliver the product to the customers. These service parts include:

- A Web site
- Just in-time inventory system
- Strategic alliances and partnerships
- Electronic payment options
- Delivery methods for the physical products.

eC in Developing Countries

The business opportunities stemming from *eC* technologies are believed to be not far from reaching for developing countries (Molla & Licker, 2005). Several studies have been conducted to investigate the potential as well as the inhibitors of developing *eC* in developing countries (Archiburgi & Pietrobelli, 2003; Enns & Huff, 1999; Hempel & Kwong, 2001, James, 2005; Kamel & Hussein, 2001; Molla & Licker, 2005; Omole Wambogo, 2001; Oyelaran-Oyeyinka and Lal, 2005; Rosenbloom & Larsen, 2003; Travica, 2002). The belief that cost reduction benefits can be realised relatively easily leads business to consider Internet applications in order to offer their products and services and support their customer. Cost reduction is the main driver for *eC* in the developing countries as well. However, studies indicate that several barriers inhibit the diffusion of the Internet (Kiiski & Pohjola, 2002) and the full exploitation of *eC* potential (UNCTAD, 2003). Privacy issues and Communication channels (Clarke, 1999), as well as faster knowledge transmission does not automatically imply that developing countries benefit from technological advances (Archiburgi & Pietrobelli, 2003; James, 2006). The digital divide between developed and developing countries that can be measured in terms of the inequality in access to Internet uses and the necessary skills and resources that can be deployed for eC development (Oyelaran-Oyeyinka & Lal, 2005) play an important and decisive role for developing countries in keeping up and taking advantage of the technological advances. In brief, while the attributes of the Internet enable *eC*, they also restrain its growth for reasons such as:

- Varied as infrastructures limitations
- Lack of trust
- Security and authentication
- Privacy protection and personal data, as well as
- Taxation.

Care must be exercised not to over-regulate electronic commerce. In its present growing state, overly restrictive regulations could suppress innovation and delay growth. At the same time, measures to promote confidence are needed also and some rules or principles may have to be established while electronic commerce is still limited and few vested interests have established themselves. In conclusion, the studies identified

- Physical
- Technological
- Institutional
- Socio-economical

barriers that discouraged developing countries to adopt *eC*. For example most companies in developing countries are of small size. This can become an advantage if it will take the from of advanced flexibility but in the case of the developing countries it means less resources, therefore difficulties to embark on *eC* projects (Goode & Stevens, 2000).

E-COMMERCE DEVELOPMENT IN SUDAN AND IN SYRIA

Methodology and Research Objectives

In order to meet the research objectives of this study, a total of 200 questionnaires were e-mailed, posted, or handed out to business and IT managers of companies in Sudan and Syria. On the whole 28 valid questionnaires were used for the study (a response rate of about 14%, lower that the average of 20% in similar type of studies). The questionnaire was tested for its validity. A second revised version of the instrument was completed by incorporating all comments after experts in ecommerce commented for its content validity. The research questions were developed by taking into consideration recent advances in Web technologies and customers' satisfaction factors (Brown, 1995; Hoffman, Novak, & Peralta, 1999) that can be potentially affected by the information technology. In addition this chapter draws on (Oyelaran-Oyeyinka & Lal, 2005) and considers the digital divide between developed and developing countries in terms of the B2C *eC* applications use, the maturity of *IS/IT* planning, the skills of employees and the problems that companies face.

The research questions follow:

- How Syria and Sudan approach eCommerce management?
- To what extend B2C eCommerce applications are developed and used?
- What are the problems that mostly these countries face with regard the development of their eCommerce portfolio?

The applications considered in this study were chosen after a careful analysis of the relevant *eC* literature and they depict the stages in the customer resource life cycle (*CRLC*) model. The (*CRLC*) model was developed by Ives and Learmonth (1984), with the aim to assist in identifying *IS* opportunities, which support business transactions between an organization and its customers. The model, which is shown in Table 1, considers 13 stages that comprise the customer resource life cycle.

It is generally accepted that an organisation's products and services go through a fairly well defined life cycle. Each stage presents a broad area where a company may focus on in an attempt to improve their services and their customers' satisfaction.

The customer resource life cycle (*CRLC*) model has been considered in earlier research studies that investigated B2C *eC*, in developed countries (Kardaras & Papathanassiou, 2000; Lightner, 2004). However, it has not been used in examining the B2C *eC* in developing countries. This chapter takes on this research task, thus contributing to the development of the necessary conceptual widely applicable framework for cross-country evaluation studies.

A five-point Likert scale was used in order to allow respondents to report the extent to which they used each *eC* application. On the other hand, space was given to respondents to report on any other application

Table 1. Customer resource life cycle by Ives and Learmonth (1984)

Thirteen-Stage Customer Resource Life Cycles
1. Establish Requirements to determine how much of a resource is required. 2. Specify the attributes of the resource. 3. Select source where the customer will buy a resource. 4. Order the quantity. 5. Authorise and pay for the purchase. 6. Acquisition of a resource. 7. Test the specifications and accept. 8. Integrate, update the inventory. 9. Monitor, control access and use of a resource. 10. Upgrade a resource if needed. 11. Maintain if necessary. 12. Move return or despose the inventory if necessary. 13. Account for/Monitor how much is spent on a resource.

they might have developed but it is not listed in the questionnaire. Finally, a number of open and closed questions were designed for the purpose of investigating the companies' technical and social problems as well as the technology in used.

Limitations of the Study

This study analyses a relatively small data set from companies from different business sectors. Although conclusions for the whole industry can be drawn, more specific sector oriented surveys will shed more light on the actual achievements and priorities of the companies with respect to their *eC* development. In addition, this survey investigates the current situation in Syria and Sudan. Surveys in other countries would also be useful for a more comprehensive and comparable results. Nevertheless, the results provide a useful indication of the *eC* development, its problems and technologies in developing countries.

Companies Profile and Management Approaches

The countries that represent the developing world are Syria and Sudan. Fifty-five percent of the sample is from Sudan and 45% of the sample is from Syria. The sample of the companies represents a wide range of business sectors. The percentages of companies in each business sector are: manufacturing 22%, government organizations 5%, service sector 41%, trade import / export 32%. The service sector includes: travel and tourism, advertising, computing and Internet services, transport and finance and investment.

Only 68% of the sample revealed their turnover, which ranges between US$1 million to US$200. 32% of the firms in the sample considered their total revenue confidential and they did not disclose it. The average income of the 68% of the sample is $22 million. The average expenditure for the IT infrastructure of the 68% sample is around $1.5 million, that is, it is the 8% of the total revenue. Again the remaining 32% of the sample firms did not reveal their IT expenses.

The average total number of employees in the companies is 176, with an average of 14 employees working in the IS/IT department. The maximum number of IS/IT staff belongs to publishing and multimedia businesses, with 70 and 65 employees respectively and that reflects the information- intensive nature of their business.

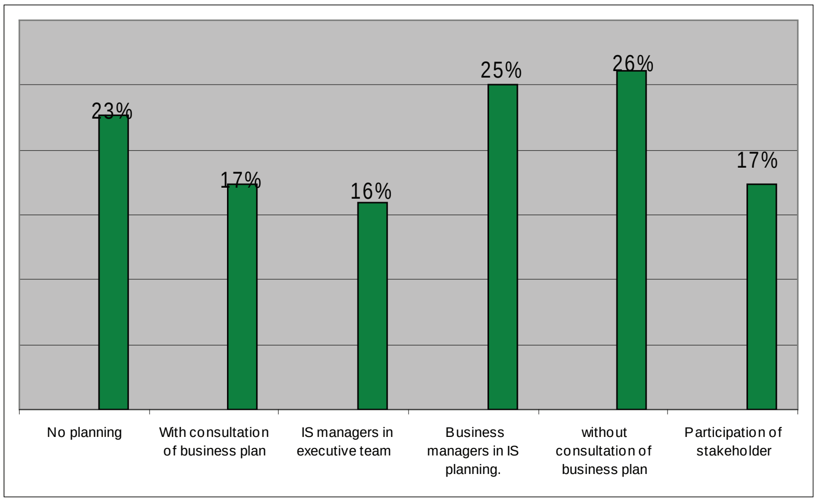
The profile of the companies of the sample is summarized in Exhibit A.

The management approaches adapted by the companies in the sample are considered in terms of their information systems (IS) planning style and *IS* project justification criteria. With respect to *IS* planning, as Figure 1 shows, 17% of the companies engage a wider range of stakeholders, that is, users, business and *IS* management in the planning process. 17% take into consideration the business plan, 26% plan for *IS* without consultation of the business plan, and 23% have

Exhibit A. Average of turnover, IT expenditure, staff & IS staff

Countries	Turnover	IT cost	IT spending	No of total staff	IT staff	IT staff/ total staff
Developing	$22 Million	$1.5 Million	8%	176	14	11.7%

Figure 1. Participation in IS planning



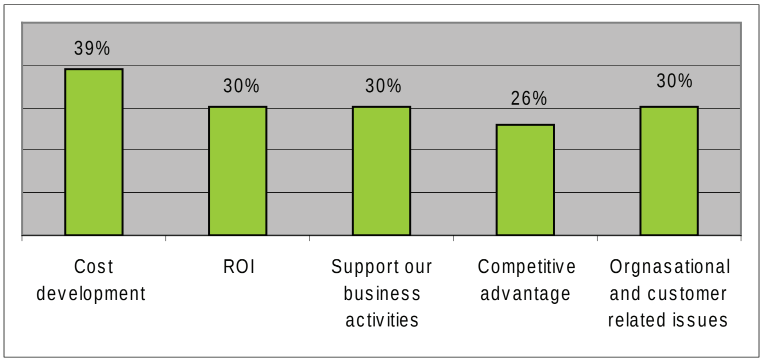
no IS plan. Additionally, a total of 59% of the sample use one or more methodologies to plan for their IS, while 41% refrain from using one. The percentages in Figure 1 exceed the 100% as companies were allowed to choose more than one option, as they could adapt more than one management practices.

Regarding the involvement of business managers in *IS* planning as shown in Figure 1, 25% of the respondents indicated that they were actively involved in the process, while only 16% of the *IS* managers happened to be members of the companies' executive team. This finding implies that the level of integration of business and *IT* is poor in the case of the developing countries. It also suggests that these companies lack an established and effective communication link between their *IS* management and their business counterparts. As a matter of fact 23% of these firms totally refrain from developing an *IS* plan while only 17% of them develop their *IS* with consultation of business plan. This indicates a low level of *IS* management maturity.

Regarding the *eC* justification and approval, as shown in Figure 2, around 69% of the companies use only financial measures, that is, cost measures and return of investment (ROI) rations. Only 30% use organizational and customer-related factors. Moreover, 30% use measures that reflect the support to their business and plans, while 26% use competitive advantage-related issues. There is a strong indication that firms in the developing countries view IT mainly in terms of cost only. Therefore, firms seem to develop IS only if the cost is relatively low. Percentages in Figure 2 may also exceed 100%, as respondents were allowed to choose more than one criteria.

With respect to business staff skills, 36% of the sample reports that their employees know how *IS*/*IT* works. 32% understand *IS* and its potential, while surprisingly, only 16% of *IT* staff know how the business operate. Once more, this finding strongly indicates that *IT* role is still considered as a merely technical function.

Figure 2. Justification and approval of IS



The Current State of *eC* Development

Table 2 shows a number of B2C *eC* applications investigated in this research. As Table 2 shows, around 46% of the companies in the sample strongly use applications that provide customers with products and service-related information such as prices, availability, new features, and so forth. Considering the simplicity of developing a Web site for the information provision and the relatively small percentage of the firms that use the Web for such a purpose, this study indicates that businesses are utterly delayed in considering the Internet for business use. Moreover with approximately 36% of the sample companies using their *IS* to support staff competence, this research indicates that the main orientation of the businesses is to support their internal business processes and to educate their staff rather than to support their customers. This finding is in line with the companies' preference of cost oriented criteria for *eC* applications justification, as shown in Figure 3, instead of adopting a wider view to evaluation incorporating customer related criteria as well.

Around 36% of the companies in the sample use strongly their *IS* in order to identify different market segments, which indicates that these organisations are aware of the usefulness of *IS* in terms of identifying new lines of businesses and future opportunities. In an attempt to provide a better support to their customers, approximately 32% of firms have developed applications that provide customer training, handle customer complaints and support customers to choose the right products or services. This finding provides an indication that there are companies, which may constitute the critical mass of businesses on a route to entering a new era of customer orientation. However, bearing in mind that service sector, that is, information intensive businesses comprise the 41% sample, a 32% of customer oriented *eC* applications may still be considered as low.

Only 25% of the sample have developed and strongly use applications that support on-time delivery. Not surprisingly, since applications that support automatic payment or supporting customers to place electronic orders have completely been left out of the *IS* priorities. This is not only due to the data security problem or lack of trust (Clarke, 1999) issue but it can also be attributed to the low level of *IT* maturity and the low level of education and computer literacy among customers in these countries. Finally, building *IT* in products and services is low (25%) as well as providing customers with administrative support (approximately 18%). Such results are more or less expected considering the technological state of these countries.

eC Development Problems

Concerning the technical, social, and managerial problems that firms in developing countries encounter, table 3 below shows to what extent organisations face each particular problem. An overview of the percentages reveals that almost all the problems listed (except the "employees' confidence") are highly appreciated as problems by at least the 50% of the sample. These problems reflect the level of the difficulties businesses face and indicate the gap of the digital divide between developed and developing counties. Technical problems, such as data security (strongly 45%), reliability (strongly 38%) and performance (strongly 35%), top the list of the main problems and they indicate the in-

Table 2. The extent to which companies use the Internet and eC for customers' support

Internet application	Not At all	Little	Moderate	Strongly	Don't Know
Give your customers information	3.57%	17.85%	28.57%	46.42%	3.57%
Use IS to support your staff's competence	3.57%	17.85%	32.14%	35.71%	14.28%
Use IS to identify different market segments.	21.42%	14.28%	25%	35.71%	3.57%
Offer Customers training to use your IS	35.71%	14.28%	17.85%	32.14%	0%
Use IS for handling customers complaints	21.42%	32.14%	14.28%	32.14%	0%
Use IS to Support customers to choose the right product or services	25%	28.57%	14.28%	32.14%	0%
Support the on-time delivery of the products or services	39.28%	21.42%	14.28%	25%	0%
Use IS to Involve customers in product design and customisation	42.85%	14.28%	3.57%	25%	14.28%
Build IT in products and services	28.57%	14.28%	21.42%	25%	10.71%
Offer Customers Administrative Support,	28.57%	28.57%	17.85%	17.85%	7.14%
Use IS to support automatic payment	57.14%	17.85%	3.57%	3.57%	17.85%
Allow customer to automatically place order	57.14%	10.71%	3.57%	3.57%	25%

adequacies with respect to the *eC* infrastructure in the developing countries. The functionality of eC applications (strongly 29%) follows in the fourth place whereas in other studies for developed counties (Kardaras & Papathanassiou, 2000) this is a high priority problem. This indication may be considered as being in line with the lack of customer orientation in the companies as Figure 2 suggests. Capturing the required functionality requires a careful planning and a higher level of understanding of the customer needs, the technology and its implications. With this respect the companies in the sample are falling behind.

Other issues concerning companies are the value for money from such *IS* (strongly 28%) and the problematic access (strongly 25%). Finally, employees' and customers' confidence along with lack of know-how appeared to be among the less problematic areas. As for employee this is a positive attitude, however, it is rather surprising that problems related to customers are not among the main problems. This can be attributed to the fact that organisations have not yet come across any requirement specification process and that managers have not yet thought carefully of their customers' requirement for e-commerce applications.

FUTURE RESEARCH

Future research may focus on investigating the level of B2C *eC* development in other developing countries, as well as the customer perception and behaviour with respect to the value of each one of the listed *eC* applications. Furthermore, a study that compares and contrasts the *eC* development and management between developed and developing countries may shed light into the reasons of possible differences as well as into the strategies for the future.

This study investigated the management views. A similar study may also focus on the customers' views, possibly with larger samples.

Research studies on *eC* portfolio development and perceived importance may contribute towards the design of *eC* evaluation methods and metrics.

CONCLUSION

This research indicates as other studies have that businesses in Syria and Sudan place more emphasis on cost related issues regarding the *eC* justification and

Table 3. Technical, managerial and social problems with the B2C eC applications development

Problem	Not At all	Little	Moderate	Strongly	Don't Know
Data Security	14%	14%	27%	45%	0%
Reliability	10%	5%	19%	38%	29%
Performance	10%	30%	20%	35%	5%
Functionality	5%	33%	29%	29%	5%
Not confident for the value for money	21%	16%	26%	28%	11%
Problematic Access	0%	35%	35%	25%	5%
Lack of Customer confidence	0%	29%	38%	24%	10%
Do not know customers' requirement	5%	20%	40%	20%	15%
Lack of employees' confidence	19%	33%	19%	19%	10%
Lack of know how	14%	29%	38%	14%	5%

approval. They focus on realising benefits related to their internal processes rather than adapting a customer centred approach to developing *eC*. The customer orientation of the companies in the sample takes the form of applications that mainly provide customers with product information.

This chapter indicates that in order to accelerate the development of eC, companies need to focus on

- Management
- Infrastructure
- Knowledge and skills

Actions should be taken in order to alleviate problems indicated by this study, but not on each issue separately, since initiatives in infrastructure improvements may follow knowledge and employees skills development.

With respect to their management organisations need to improve their management strategies and approaches in systems planning, justification and approval. There is a need for the development and use of an extended set of *eC* evaluation criteria that would include customer-oriented metrics. This will facilitate the shift of the merely internally focused thinking to considering the customers as well. In turn, such a shift will possibly boost the confidence for development of B2C *eC* among management, employees and their customers and it will probably lead to the development of more advanced and sophisticated B2C *eC* applications. Data security although is reported as a technical problem that comes on the top of the list is a management problem as well that has not only its technical side, but its social one. It an international problem that holds back B2C *eC* and prevents it from reaching it's full potential. It is not just a characteristic of the developing countries. It is a strong indication that customer are reluctant to reveal their personal information over the Internet. Security however, should be achieved with careful design of the technological solutions and management initiatives, such as compensation of potential losses, insurance policies, customer training courses, etc. All these require funding, which is also an issue as this research indicates that spending on *IS/IT* is only at 8% of the total income.

Infrastructure problems are expressed mainly in terms of performance and reliability of eC applications. These issues have been reported in other studies as well (Kardaras & Papathanassiou, 2000). In general regardless if there is the case of a developed or a developing country the reliability of a eC application, that is, an eC service has not been yet defined neither have standards been formalised.

In addition, as regards knowledge and skills, fostering staff development schemes businesses will have the opportunity to engage their employees into more customer oriented thinking as well as exploiting more of the available eC technological infrastructure. The management should also take initiatives that improve customers and employees knowledge and confidence with *eC*. Lack of know how, poor knowledge of the required functionality and customers reluctance to using the Internet are top priorities for lifting them from the list of *eC* development problems.

This research finally supports the findings of other studies such as (Archiburgi & Pietrobelli 2003; James, 2006; Omole Wambogo, 2001; Oyelaran-Oyeyinka & Lal, 2005) that faster knowledge transmission does not automatically imply that developing countries will benefit from the technology. This study supports that a systemic and systematic approach towards developing the necessary management culture will accelerate B2C eC development, it will enable customer to participate and all engaging stakeholders to benefit.

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KEYWORDS

Collaboration Platforms: These models provide a set of tools and an information environment for collaboration between enterprises. This model can focus on specific functions, such as collaborative design and reengineering, or in providing project support with a virtual team of consultants. Business opportunities are in managing the platform, and in selling the specialist tools. Examples are in the products and projects spun off from the global engineering network concept (Rethfeldt, 1994).

E-Shop: This is a Web marketing of a company or a shop to promote the company and its goods or services or both. This business model is kind of incorporating the traditional version of *eC* with *eC*. Both customers as well as the company benefit from this model. Benefits for the customer include lower prices, wider choice, better information and 24-hour availability. Benefits for the business include increased demand, and cost reduction in sales and promotion.

E-Mall: An electronic mall, in its basic form, consists of a collection of e-shops, usually enhanced by a common umbrella, for example a well-known brand may be enriched by a common granted payment method. The e-malls operators may not have an interest in an individual business that is being hosted. Instead the operator may seek benefits in enhanced sales of the supporting technologies (e.g., IBM with World Avenue). Alternatively benefits are sought in services (e.g., Barclays with BarclaysSquer), or in advertising space and/or brand reinforcement or in collective benefits for the e-shops that are hosted such as traffic, with the expectation that visiting one shop on the e-mall will lead to visits to neighboring shops.

E-Auction: Electronic auctions offer an electronic implementation of the biding mechanism known from the traditional auctions. E-auctions can be accompanied by multimedia presentations of the goods. They also include integration of the bidding process with contracting, payments and delivery. Benefits for suppliers and buyers are increased efficiency, timesaving, and global sourcing.

E-Procurement: This is an electronic tendering and procurement of goods and service. Large companies or public authorities implement some form of e-procurement on the Web. Benefits for the buyers include a wider choice of suppliers to choose from which in turn leads to lower costs, better quality, and reduced cost of procurement. The benefits for suppliers, however, include more tendering opportunities, lower cost of submitting a tender, and tendering in parts. An example is Japan airlines.

Third Party Marketplace: This is an emerging model that is suitable in case companies wish to leave the Web marketing to a 3rd party (possibly as an add-on to their other channels). Several additional features like branding, payment; logistics, ordering, and ultimately the full scale of secure transactions are added to the 3rd party marketplace. Revenues are generated on the basis of one-off membership fee, service fees, transaction fee, or percentage on transaction value. Examples of 3rd party marketplace providers are Citius (Jellasi & Lai, 1996), and Tradezone (tradezone.onyx.net).

Value Chain Service Provider: These specialize on a specific function for the value chain, such as electronic payment or logistics, with the intention to make that into their distinct competitive advantage. A fees or a percentage is the basis for revenues. Examples of value chain service providers are FedEx or UPS Web-based package shipping support.

Value Chain Integrators: These focus on integrating multiple steps of the value chain, with the potential to exploit the information flow between those steps as further added value. Revenues come from consultancy fees or possibly transaction fees.

Virtual Communities: The ultimate value of virtual communities is coming from the members who add their information into a basic environment provided by the virtual community company. The membership fees as well as advertising generate revenues. A virtual community can also be an important add-on to other marketing operations in order to build customer loyalty and receive customer feedback. An example of a virtual community is Amazon.com for books. Virtual communities are also becoming an additional function to enhance the attractiveness and opportunities for new services of several of the business models (e.g., e-mall or 3rd party).

BISER

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INTRODUCTION

The Simon's model of the decision-making process includes the phase of choosing among alternatives or options, designed for solving the given problem. Usually an option dominates in some of the properties and is less suitable according to others. Making a rational decision in choosing an option means to balance between different properties. There are two principle strategies in performing this task:

- To evaluate every option on the whole set of properties, and
- To apply a procedure to extract the best (the most suitable) one.

Integration of information associated with the multiple properties of competitive options into a single measure is presented and discussed. Options could be goods to purchase, list of products for manufacturing, suppliers, services, technologies, and even candidates for a given position. The common in all such cases are:

- The decision maker has to assign a value to every option in the competing group by comparing it against its alternatives—the other members of the same group. Further, we shall call this value **integral quality indicator** of the option.
- Options in the group are described with a common list of properties or characteristics, which we will call further **single quality indicators** of the option.

Different measures, designed to integrate the information provided by single indicators, are presented and discussed.

INFORMATION MODEL: NOTATIONS

The elements we will use further are presented in Table 1:

- $O = \{O_i\},\ i = 1,\dots n$ is the group of options;
- $I = \{I_j\},\ j = 1,\dots,k$ is the set of single indicators;
- $X = \{x_{ij}\},\ i = 1,\dots,n;\ j = 1,\dots k$ is the information matrix, holding the value of single indicator I_j for option O_i;
- $W = \{w_j\},\ j = 1,\dots,k$ is the vector of weights, where w_j measures the value (importance, significance) of the indicator I_j;
- $S = \{s_j\},\ j = 1,\dots k$ is the vector of signs, where s_j represents the direction of increasing the quality of options according to the change of the value of given indicator: "'+1" indicates "the higher value of the indicator the higher quality of the option" and "-1" indicates "the higher value of the indicator, the lower quality the option." In this case, when quality of the option, measured according to indicator I_r, depends on the distance from a given finite value y_r, and it is the highest when $x_{*r} = y_r$, we may apply the following transformation $x_{jr} = abs(x_{jr} - y_r)$ and set the sign as $s_r = -1$.

INTEGRAL INDICATORS

Integral indicators are functions I, which transform a vector $\{x_j\}$ of real numbers into a single real number Q, where $j = 1, 2, \dots, k$.

$$I : R^n \to R$$

B

Table 1. Information model

				option 1	option 2	...	option n
indicator	**dimension**	**weight**	**sign**	O_1	O_2	...	O_n
I_1	D_1	w_1	s_1	x_{11}	x_{21}	...	x_{n1}
I_2	D_2	w_2	s_2	x_{12}	x_{22}	...	x_{n2}
...	...	...	...	...	...	...	...
I_k	D_k	w_k	s_k	x_{1k}	x_{2k}	...	x_{nk}

Weighted average (Additive Integral Indicator) is the most often used integral indicator:

$$I(O_i) = \frac{1}{\sum_{j=1}^{k} w_j} \sum_{j=1}^{k} w_j q_{ij}, i = 1,2,...,n,$$

where

$$q_{ij} = \left(\frac{x_{ij}}{\overline{x_j}} \right)^{S_j} \text{ and } \overline{x_j} = \frac{1}{k} \sum_{i=1}^{n} x_{ij}.$$

It is easy to interpret results achieved by weighted average but if single indicators are not independent, a hidden bias may influence the result. This indicator may lead to misinforming, when the values of single indicators are spread near the boundaries of their domains. In this case, a poor value of one indicator can be compensated with even tiny dominance of another even less important indicator.

To avoid the later problem, a multiplicative integral indicator (see Boneva, Dimitrov, Stefanov, & Varbanova, 1986) was constructed:

$$I(O_i) = \prod_{j=1}^{k} q_j^{w_j}, i = 1,2,...,n,$$

where $\{w_j\}$ are appropriately normalized, and q_{ij} has the same meaning as in additive formula. Independence of single indicators is required as well. The quantity of information (using Shannon's formulae) obtained by this integral indicator is equal to the weighted sum of quantities of information provided by single indicators (see Christozov, 1997):

$$\log_2 I(O_i) = \sum_{j=1}^{k} w_j \log_2 q_j, i = 1,2,...,n.$$

The difficulty in interpreting this measure in the problem domain may cause misinforming. It also assumes independence of single quality indicators.

BISER (Christozov, Denchev, & Ugarchinsky, 1989) is an algorithm, exploring between indicators dependences, which constructs a family of integral indicators. Linear regression is used to assess the existing dependency between a pair of indicators I_v and I_w. Four simple regression models are used, obtained via transforming original data by taking logarithms of the values of either one or another or both of the vectors, representing indicators I_v and I_w, which are used in evaluation of the regression coefficients:

model 1: $x_v = a_{vw} + b_{vw} x_w$
model 2: $x_v = a_{vw} + b_{vw} \ln(x_w)$
model 3: $x_v = \exp(a_{vw} + b_{vw} x_w)$
model 4: $x_v = \exp(a_{vw} + b_{vw} \ln(x_w))$

The model that gives the highest correlation C_{mvw} is selected. The correlation coefficient is used also as a measure for the between indicators dependency. The intermediate result consists of the four matrices:

regressions' coefficients $A = \{a_{ij}\}$ and $B = \{b_{ij}\}$
correlation coefficients $C = \{c_{ij}\}$
selected model $M = \{m_{ij}\}$

Integral indicators are constructed by choosing one of the single indicators ***g*** as an argument in all selected models. The normalized values q_{ij} are calculated by:

$$q_{ji} = \left[\frac{x_{ji}}{f\left(a_{ig}, b_{ig}, m_{ig}, x_{ig}\right)} \right]^{s_i}, \; j = 1,2,\ldots,n; i = 1,2,\ldots,g-1, g+1,\ldots,k$$

where

$$f\left(a,b,m,x\right) = \begin{cases} m = 1 & a + bx \\ m = 2 & a + b\ln(x) \\ m = 3 & \exp(a + bx) \\ m = 4 & \exp[a + b\ln(x)] \end{cases}$$

The integral indicator is constructed with the formulae:

$$Q\left(O_i\right) = \frac{1}{\sum_{j \neq g} w_j c_{ij}} \sum_{j \neq g} w_j c_{ij} q_{ij}, i = 1,2,\ldots,n$$

There are two special cases:

- *m=1* and *{*b_{ij}*=0}* represents the additive indicator
- *m=4* and *{*b_{ij}*=0}* – the multiplicative one

Exploring between indicators dependency instead of assuming their independence, together with automatic selection of the model, based on available data, allows working in the terms of problem domain preserving both the mathematical correctness on the entire data space and the interpretability of the results.

CONCLUSION

The following properties of technology BISER, the proposed integral indicator, are valuable in applying for comparative evaluation of options' qualities:

Simplicity:
- Using domain terminology in presenting data, preferences, and relations;
- Easy to interpret, does not set any extraordinary requirements to data, which may confuse users or which may require background and qualification beyond the problem domain;
- Flexibility to perform simulations with computers.

Natural requirements for data:
- The method does not require preconditions, which are difficult for proving, for example, independence between indicators.
- Using simple models allows the evaluation of their parameters and achievement of results even with small number of observations.

Heterogeneity of data: The proposed method is not as sensitive toward the homogeneity of the set of options. BISER allows existence of reasonably small quantitative shifts among them and even benefits from such diversity.

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KEY TERMS

Integral Quality Indicator: A single value characterizing a group of properties of a given option.

Option: Alternative solution of given problem.

Quality Indicator: A single value characterizing particular property of a given option.

Blended Approach Environment Shift in Higher Education

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INTRODUCTION

The use of educational technology at university and college campuses has grown and changed substantially in the last decades. The province of computer and other forms of technology are now being used for multiple functions in diverse educational settings. At many universities, the lecturer uses the software available to organize lecture notes and e-mail and electronic forums to communicate with their students. Inside the classroom, computer projection systems are replacing traditional overhead transparencies, making it possible to harness the interactive and visual capabilities of the computer for lecture and group activities.

The problem faced by any university '*is how to structure itself so that it's central academic activity is facilitated, not undermined by technological development*' (Laurillard & Margetson, 1997). Even though universities appear to be more comfortable with traditional forms of teaching and learning, it appears that a shift toward a blended approach is taking place by universities that are trying several different forms of educational technologies to find the right fit. Students often do not want to lose the unique attributes of face-to-face teaching, but they do wish for the benefits of educational technology such as edutainment learning.

BACKGROUND

The landscape of higher education in Malaysia is rapidly being reconfigured as new media technologies are supplementing conventional teaching practices (Bajunid, 2005). The acceleration of e-learning facilitated by information and communication technology (ICT) is stimulated by dismay with current didactic practices which appears to stem from ancient times, as faculty today seem to teach in the same way as Aristotle or Plato did. Despite initial resistance by some academics who fobbed e-learning off as a passing fad, proponents have embraced the use of ICTs for the many pedagogical promises that it holds (Rosenberg, 2001).

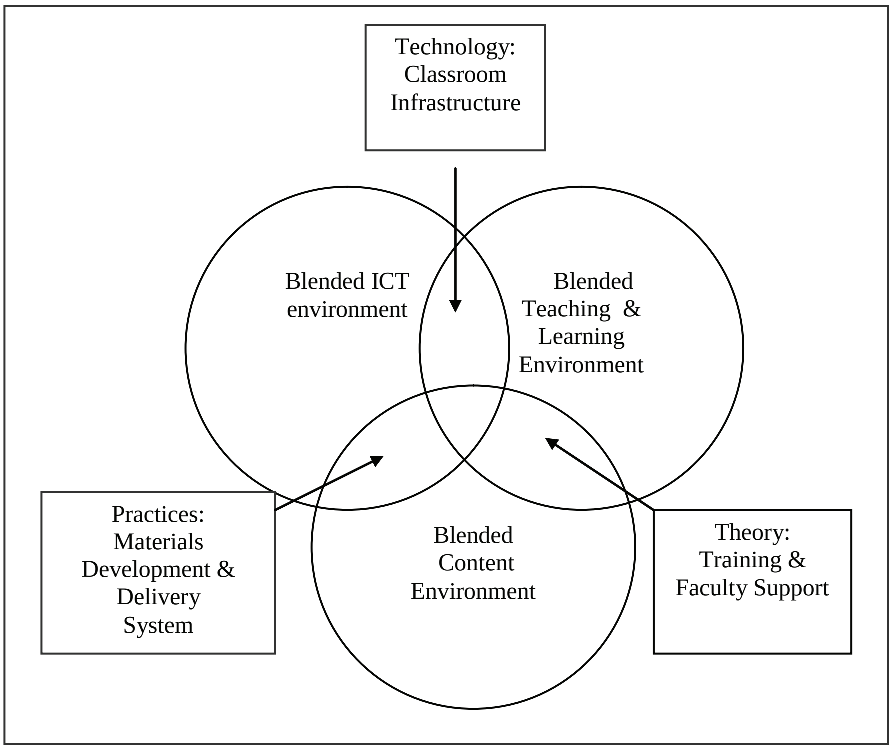
Even though higher education has appeared to be more comfortable with traditional forms of teaching and learning (Laurillard, 2002), it appears that a shift towards a blended approach to training is taking place as higher education institutes are trying several different forms of technology to find the right fit. Reports from the higher education sector identify similar trends. Learners most often do not want to lose the unique attributes of face-to-face teaching, but they do wish for the benefits of online learning (Bates, 2003). Thus, other research has shown that students who have participated in blended learning were more likely to take an online course in the future even though blended learning is not simply a matter of the combination of face-to-face and online instruction, but it has to have elements of social interaction (Heinze & Procter, 2006). There are three factors based on the three types of blended environment: blended IT environment, blended teaching and learning environment, and blended content environment, as shown in Figure 1.

Figure 1 represents the conceptual design of the research and the specific phases of research that will be conducted. As Figure 1 illustrates, the blended IT environment can be categorized by using technology platforms from a variety of sources. Meanwhile, for blended teaching and learning environment, instructional technology and pedagogical methods strategies that reflect on teaching and learning situations are used. Blended content environment is used towards the development of content to accommodate a variety of learning styles, teaching approaches, and available technology tools. The blended approach can be useful if the educators will understand the conceptual phases in their strategies towards the blended approach in an e-learning environment for higher education.

BLENDED APPROACH IN HIGHER EDUCATION

The term "blended learning" has been defined as method of educating that uses technology combined

Figure 1. Diagram of conceptual design for the blended approach



with traditional (stand-up) education or training (Smith, 2001) or "learning that employs multiple strategies, methods, and delivery systems" (Saunders & Werner, 2002). Meanwhile, Troha (2002) describes the term "blended learning" as combining the best features of online learning with the best features of classroom instruction. The blend may be a single instructional method combined with a presentation and distribution method, or a combination of multiple methods. In this article, the blended approach is taken into consideration as a combination of traditional or current educational technology that is provided for the educators and also some constituents of instructional process are facilitated online while other constituents are offered conventionally.

The critical factors for success will change with the implementation of the blended approach; prior experience of using technology; the and technological infrastructure. The lecturer will be the new key element in the success of the learning experience. Universities can help students achieve success by a combination of theory, technology, and practice. First, the blended ICT environment, or the functionality of technology infrastructure, should be ensured before the course is implemented. This should be backed up by technical support from either the lecturer or technological expert. Second, in the blended teaching and learning environment, human resources should be committed to the project at an early stage and lecturers should be selected based on their attitudes towards technology, teaching style, and ability to control the technology. Finally, in the blended content environment, where subject domain which material development and also the delivery system suitable the method approach. This is a paradigm elaborated in debates about existence, significance, and causes of the shifts towards neo and post-Fordism in the organization of work to which ICTs are argued to be central (Edwards & Usher, 2000).

Blended ICT Environment

E-learning systems open up new perspectives on knowledge transfer. Providing valuable content and elaborate interactivity structures could encourage the learner to discover knowledge on one's own initiative in a constructivist fashion. Applying Semantic Web technologies to e-learning systems will facilitate a new generation of e-learning systems (Smith, 2001). The current pioneers are introducing digital technologies into the educational process at a time when the technology is still quite crude in comparison to full the bandwidth of the typical classroom (Saunders & Werner, 2002; Scott, 2001; Spodark, 2003). During this introductory period, with little evidence of correct usage, instructional practice can easily be dominated and directed by technology. In the context of the Malaysian universities experience, this seems to be a reality which is examined thoroughly via the hardware and software setup of the schools, and the technological support convert in practices and policies will determine whether instructional practice can be directed successfully by technology.

When the technology of education dominates, learning theory is supplanted with instructional practice, which is technology dependent. The introduction of poor technology into education can easily have a constrictive rather than empowering effect. "*Technology is seen as a monster which threatens all the value of society, a dehumanizing influence which must be resisted*" (Romiszowski, 1981), and in some cases, Romiszowski's sarcasm gets borne out. When government funding of technology is lacking or poorly implemented, institutions must seek sponsorships and alliances which creates a relatively new triad consisting of education, markets, and information technology, charity from business, rather than taxation of business, and puts power in the hands of business to set the agenda for education (Kenway et al., 1994). Most of the higher education has responded by adopting ICTs as part of the training for academic staff and students to maximize the usage of ICT capability in their organizations.

Blended Teaching and Learning Environment

Teaching and learning environments often tend to forget when the higher education more forecast on technology. Higher education has embedded the ICT technology as a medium of communication, either synchronous or asynchronous (Becker, 2000). These tools are divided just because of their usage in the teaching and learning environment. There are five pillars for synchronous and asynchronous to take part in the ICT technology:

1. The communication between students and peers
2. The communication between lecturer and students
3. The communication between students and technologies
4. The communication between students and subject content
5. The communication between students, lecturer, and industries

Synchronous communication tools are tools that enable real time communication in a "different time–different place" mode. These tools allow people to connect at a single point in time, at the same time (Kaplan & Ashley, 2003). Some features that include in the synchronous communication are:

- Text conversation, which can include pictorial support.
- The ability of users to ask, answer, or comment on something in the Internet.
- The ability of users to listen and respond while all the group members are present in an online conversation.
- The ability of users to follow a conversation that is presented in the order that the text is written, which can appear out of sequence to viewers.
- The ability of users to manipulate files through file sharing activities and the integration of Web links, images, and sounds.

Moreover, asynchronous communication tools are tools that enable the users to work in their own pace or self-directed usage. More importantly, asynchronous student-to-student and student-to-teacher interaction have been noted as the most important forms of interaction when build an online component to a course (Soo & Bonk, 1998). The review also revealed that interaction is critical when maintaining a student's level of satisfaction (Fulford & Zhang, 1993). Finally, the creating of blended learning strategies can provide an opportunity which utilizes the best of multiple environments (Zenger & Uehlein, 2001) and, when designed appropriately, can help improve interaction and student satisfaction.

In addition, for the realization of particular methods, a teacher is often bound to the *subject domain* taught. For example, though project-based learning is a desirable educational goal, it is difficult to realize in a sports lesson. Likewise, the integration of e-learning has to be seen more strongly in its relation to the particular subject domain; math courses might be more strongly related to a usage of e-learning than might be the case for domains like musical education or sports.

According to Lim (2002), all individuals (teachers, learners, parents) participating at a teaching and/or learning practice come together in a *learning community*. Among others, the community sets standards for how students interact with each other, how communication should look between teachers and students, and how parents are involved in learning and teaching practice. The interaction among the several participants represents a strong subsystem, which depending on the particular school exhibits unique rule systems and rituals.

Last but not least, the quality as well as the form of e-learning is crucial for a consideration of teaching and learning practice. Beneath aspects like usability and ease of use, for each kind of software, several teaching and learning practices are possible. For example, e-learning can be used either as a tool (e.g., writing and graphics programs), as a medium for communication (e-mail, chat, instant messaging), or as a means to store and distribute teaching and learning materials (databases).

Blended Content Environment

In designing ICTs, programmers as stakeholders have to take particular criteria into account: software has to meet user needs. Decision makers especially were concerned about a high ease of use, cost-effective purchasing, and administration opportunities as well as a high potential for integrating the particular software into already existing software and hardware structures. They further recommended software, allowing for student tracking and online assessment.

In contrast to higher education, for school settings, opportunities for student assessment are interesting, as they often restrict opportunities for cheating. Further, software is supposed to satisfy the anytime/anywhere concept, especially because it allows for a variety of new opportunities for teaching and learning with ICTs to develop. That way, absent students are enabled to catch up with the class progress, and absent teachers are enabled to provide substitute teachers with relevant information. Further, they are enabled to continue to supervise the lesson in a peripheral manner although unable to take part physically. By using new synchronous and asynchronous communication tools (e.g., e-mail, chat, shared whiteboard), new opportunities for collaboration emerge.

Course planning in universities involves balancing multiple objectives. Through years of experience in face-to-face teaching, faculty members have generated a great deal of knowledge and skill, which is often categorized by automatic routines and tacit knowledge. The advent of Web and the growing of multimedia technology in the education industry is transforming this context. It requires new course design procedures to represent and teach content in new contexts. It requires the use of new tools as well as the creation and transformation of artifacts. It also poses new problems that require new kinds of support and collaboration since the faculty members may lack the technical ability to create their own blended course classes (Epper & Bates, 2001).

CONCLUSION

The critical factors for success will change with the implementation of the blended approach; prior experience of using technology; the technological infrastructure; and the lecturer will be the new key elements in the success of learning experience (Cannon & Newble, 2000; Chao & Stovel, 2002). Universities can help students achieve success by a combination of theory, technology, and practice. First, the blended ICT environment, or the functionality of technology infrastructure, should be ensured before the course is implemented. This should be backed up by technical support from either the lecturer or technological expert. Second, in the blended teaching and learning environment, human resources should be committed to the project at an early stage and lecturers should be selected based on their attitudes towards technology, teaching style, and ability to control the technology. Finally, in the blended content environment, where subject domain which material development and also the delivery system suitable the method approach. This is a paradigm elaborated in debates about existence, significance, and causes of the shifts towards neo and post-Fordism in the organization of work to which ICTs are argued to be central (Edwards & Usher, 2000).

E-learning is made up of several methods of learning, which are enhanced or facilitated by technology. Technology implementation often stimulates teachers to present more complex tasks and material (Romiszowski, 2004). Furthermore, technology will tend to support teachers in becoming "facilitators." It delineates the kind of classroom interaction that will establish a comfortable and respectful environment to promote a culture for each learning style in the blended environment. This will include managing classroom procedures and creating an environment of respect and support. At this point of knowledge, the understanding of the blended approach flow and communication tool is needed to support and deliver between the ideas and technology to enhance e-learning in higher education.

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KEY TERMS

Asynchronous Communication Tool: A tool for the event in which the students communicate at their own pace of time and anywhere. Examples are self-paced tools such as chat rooms, e-mail, discussion group, or Web-based communication tool via Internet or short messaging system (SMS) via telecommunication.

Blended Approach: Generated contextualized guideline when teaching and learning in higher education whereby the technology is available for educators to combine the face-to-face (in physical classroom which supplemented with other electronic media such as video, interactive CD, etc.) and virtual classroom (Web-based approach or online system).

Blended Content Environment: Used towards the development of content to accommodate a variety of learning styles, teaching approaches, and available technology tools including ICTs.

Blended ICT Environment: Using technology platforms from a variety of sources, either physically or virtually. This includes the ICT technologies which always support higher education.

Blended Learning: The integration between one or more instructional methods which is applicable in face-to-face and also supplemented by other media such as other e-learning tools or ICT tools for communication, either synchronous or asynchronous.

Blended Teaching and Learning Environment: The usage of instructional technology and pedagogical methods strategies that reflect on teaching and learning situations. It also considers the multi-agent support for teaching and learner support.

Synchronous Communication Tool: Consider the physical classroom equipped with the ICT tools for teaching and learning that also support the communications tools between educators and learners in real-time. Examples are computer support workgroup system (CSCW) or computer-mediated communication (CMC) where the students interact with the educators via telephone or face-to-face supported by other media.

Children and Computers

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INTRODUCTION

Engagement, effort, pleasure, concentration, happiness in exploring, trying and producing ideas, experience and performance, cooperative action, all these aspects are very conspicuous when we observe young children using computers in educational settings. They seem to love technology, computers, and digital networks. How can we observe the way they approach, explore, discover, and use these very special cultural artifacts (computers and digital networks), how can we investigate the ways in which they interact with them? We probably need a "phenomenology of motivation" (Lumbelli, 2000, 2001a, 2001b) aimed to develop educational eyes capable of seeing children, who are experimenting and learning with ICT. This would provide a basis to develop and organize learning paths and tools which may make the most of children's energy while avoiding to waste their happiness to connect. Today, observing and studying the way children gain interest, explore and use computers, whether individually, with other children or with an adult, is a key issue in early childhood education, as it is connected with adults' educational ideas, and their influence on relations and teaching practices, as well as with the roles children can play as mediators of shared experiences (Bove, 2004; Ferri, 2004, 2005; Ferri & Mantovani, 2006; Mantovani, 1998; Mantovani & Musatti, 1996). The research project presented in this paper studies how children and adults explore the potential of new technologies in family and preschool settings. We took as our starting point some shots videotaped and discussed through focus groups with teachers and parents, following the approach outlined by Joseph Tobin in the study "Preschool in Three Cultures: Japan, China, United States" (Mantovani 1998, 1996; Tobin, Wu, & Davidson, 1989).

RESEARCH GOALS AND THEORETICAL BACKGROUND

The goals of the research are:

- Understanding the ways in which 3 to 6 children use and explore new digital technologies and interpret their meanings and functions at home and in preschool settings;
- Exploring teachers' and parents' ideas and representations with regard to the use of computers, at home and in preschools, and to their educational roles;
- Working out a methodological approach for the study of these issues in early childhood settings and for eliciting and making explicit the educational models;
- Stimulating opportunities for dialogue and interpretation on issues like education and technologies, learning tools in the early years, collaborative learning, and so forth;
- Developing training materials based on this approach. with computers in the early years;
- Outlining patterns for the development of "new" media education for teachers and schools.

The basic assumption of our research is that in order for teachers and parents to promote an effective and critical use of new technologies in the early years (especially in preschools) they need to gain a deeper understanding of the way in which children *spontaneously* approach these technologies together with an improved awareness of adults' representations and ideas (Ferri & Mantovani, 2006). Too often computers and digital technologies are introduced in early childhood contexts without adequate understanding of their cultural meanings, cognitive, and social potentials or constraints, which is particularly true in preschool settings as shown by Varisco (2002) and Albanense, Migliorini, and Pietrocola (2000).

On these grounds, our research focuses on exploring the way in which young children approach computers, how they relate to theses tools (both at an individual level and at a social level), what they do with them and what they think about them. Along with observing children, we aimed at understanding the way in which teachers and parents interpret the role of technologies in early childhood education and their educational responsibilities.

Having among its goals a broadening of our theoretical understanding and the development of training materials, our research is based on the assumption that creating dialogue opportunities (focus groups) may promote higher awareness and deeper understanding of the role played by new technologies in the early years. Creating this kind of dialogue may also help provide a sound basis to the design of a way "*to mediate*" the introduction of technologies in early childhood (Rogoff, 2003, 2001; Siraj-Blatchford, 2004).

Observing the first natural approaches to computer and web technologies, the changes in systematic use of tools, the cognitive strategies and the relational patterns involved is a way to clean up our minds from adults' prejudices on children's use of technologies. For example, videotaping and observing young children in front of computers helps us understand how the solipsistic concerns and the social exclusion concerns associated with the use of computers are only teachers', parents' and scholars' fears: young children always approach computers and networks in a cooperative way and get bored of them very fast. Obviously, we are talking about educational software and not about videogames (Ferri & Mantovani, 2006, pp. 75-121**)**

As early as the 1980s, Robert Taylor (1980), in his book *The Computer in the School: Tutor, Tool, Tutee*, put forward the idea that, at school, digital technologies could play three different roles: tutor, tool, and tutee. It's clear that each of these roles depends on the kind of dialogue established between the computer, intended as a teacher, and the student. Some software thought to teach, stimulates a real dialogue between children and computers. In the same way, on line communication software mediates symmetrical and unsymmetrical communication between teacher and student and through specific interfaces. They moreover permit a new kind of technology mediated of peer-to-peer relationship. In spite of that, only a few scholars, has yet defined a way to study how analyze the relationship between children and computers and a way to understand educational and communicational patterns that children work out with digital learning tools. Some suggestion can be founded in the work of same pioneer of this research field, Marc Prensky (2001), Don Tapscott and Anthony Williams (1998, 2006), Win Veen (2006). They spoke about a new generation of learners identified by the metaphor of the Homo Zappiens.

This metaphor represents, for these scholars, a generation that was born inside a digital world and a "computer screen as a window to the world" (Tapscott, 1998). This generation has grown up with technology and learns through computer screens, pc-games, exploration, and show non-linear learning behaviour.

The New Millennium learner are not born in the Gutenberg Galaxy. They are digital kids, navigate efficiently and effectively through digital information, they know how to communicate, and how to build effectively knowledge in a network of peers. Experiencing these digital information flows, kids develop an exploratory learning approach trying to give meaning to the information provided (Veen, 2006). As learners they adopt an exploratory approach, just like in gaming, they start learning without knowing the real goal of tasks. "They define their own goals, finding out the available tools and defining the appropriate strategy to achieve their goals" (Veen, 2006). Through this exploratory approach kids develop a number of meta-cognitive skills directly related to learning. They are self-directed learners, and they adopt very often a problem solving approach to learning subjects. This behavior looks like a consequence of the use of technologies. New Millennium learners have worked out new strategies that contrast with those of the former Gutenberg learner's generation. They are also an "open source generation"; cooperation for them is better than competition. They show a different behavior in dealing with learning and communication. "What appears crucial here is that learning has evolved from an individual activity of internalizing knowledge towards a social process of externalizing knowledge. Although educational theories have stressed this social activity of learning even before technology became predominant in the lives of young learners, it is through technology that humans have now become nodes in technical networks" (Veen, 2006).

These are fruitful hypotheses and this is a fruitful field of research, if related with an experimental field analysis that can permit us to verify these issues.

Our research goal is to understand the role that digital technologies may play in the different learning phases of child cognitive development. Therefore, it will be very important to study the way children gain interest, explore and use computers and get bored with technologies. And it will be very important to do so, observing children on their own, with other children or with adults, because this melts with adults' educational ideas, with related consequences in educational relations and in didactics, and with the behaviours of children as mediators of shared experiences in online environments of cooperative construction of knowledge.

To achieve these goals it will be necessary to consider critically and deeply investigate filmed video material also in order to understand some specific educational aspects:

a. The meaning of the expression "projects for digital education", both in CMC and hyper textual environments, with special attention to the design of hardware and software interfaces. Some software propose an institutional, repetitive use of technology, but is there an "effective" way for introducing computers in preschool settings and for promoting user-friendly patterns of interaction with these tools in the early years?
b. The way digital tools (hardware and software) can be approached by children of different ages. It's important to analyse the role of some instruments/tools (keyboard, mouse, and screen) and it is also important to study the best way to design these output and input peripherals according to children's needs;
c. Analysing the best way to introduce children to usage of cooperative tools for on line communication (LCMS for e-learning), in order to avoid communicative autism that some e-learning methodologies imply.
d. The definition of concrete learning paths with the aim to help political stakeholders teachers and parents to be able to overcome the "digital divide" with their children.

METHODOLOGY

The core method of this study follows the approach taken by Tobin, Wu, and Davidson in the seminal study "Preschool in three cultures" (1989) and combines the use of video as "stimuli" to provoke discussions and sharing among adults with some qualitative research tools, such as narrative interviews and focus groups. We have done videotapes with 3-6 children and computers (at home and in preschool) and we have used them not "primarily" as data, but as tools to stimulate a multi-vocal dialogue (Bove, 2004). Three municipal preschools have been involved in our research and others will be involved in the future. (*Scuola Comunale Clericetti, Milan; Scuola Andersen, Vimercate, Scuola Costa, Milan; these schools are also part of the "Bambino autore project", www.bambinoautore.org).* So far, videotapes have been discussed with teachers and the discussion will be extended to parents in the second phase of our research (Bers, 2004).

We assume that the way in which children explore and use computers (individually, with other children or with adults) is strictly linked to the adults' ideas and beliefs and to their educational models and representations. In our study, the voices of parents and teachers will therefore enrich our interpretations and extend the repertoire of possible educational practice with technologies. We also assume that by studying the way in which children approach computers will promote higher awareness of how children can be considered as "mediator" of a broader collaborative experience of learning based on the use of digital technologies.

We will also conduct some microexperiments using our previous findings as the starting point for creating settings of "semiexperimental observations"; this will help us create educational settings for cooperative learning and e-learning with children.

DESCRIPTION OF THE RESEARCH PROGRAM

Our research program includes the following phases (most of them already accomplished) :

1. Observation of children-computers interaction based on an "etnographic-visual dialogical" approach that considers learning situations as social contexts, with the purpose of generating a qualitative field of research. This phase combines qualitative research tools (observations and interviews) with anthropological research tools, usage of video materials as reactor and focus groups (Tobin Wu, & Davidson, 1989). Direct observation will be one of the tools used during the research on the field. Paths of observation will be created, using narrative and descriptive

modalities, together with "almost experimental" methods. Videos will be taken both in family and schools settings. Based on this, it will be easier to formulate the hypothesis that will lead the "almost experimental" observation, which can be modified or improved by the observer.

2. "Micro experiments" by which it will be encouraged the control of some explorative behaviours with ICT on the part of children. Field observations on the use of some tools and cooperative environments of e-learning were conducted in several schools:

    - Scuola Comunale Clericetti, Milan;
    - Scuola Andersen, Vimercate;
    - Scuola Costa, Milan;
    - The group of Scools that participate in the project Bambino Autore (www.bambinoautore.it)

3. Discussion of videos and observation highlights in focus groups with teachers and parents to build and validate the first data collected through observation based on a dialogic and narrative approach, with the aim of creating exchange and sharing of the hypothesis formulated on the collected material by the research group with teachers and parents. The Video made during the first phase will be used to stimulate exchange among participants according to the method of visual and vocal ethnography already experimented (Tobin, Wu, & Davidson, 1989)
4. This phase provides for discussion of first findings based on field observation and research hypothesis, through interviews, research meetings and focus groups organized by researchers, national and international public and private research and teaching Institution.
5. Design and development of supporting tools (virtual classroom, KM tools) for children and teachers communities, with the aim to create, share and manage knowledge according to the co-constructed method of introduction of ICT in school. This technological part of the project has been developed as a part of the LCMS open source Docebo. This LCMS system has been designed by the software house Docebo srl, in cooperation with the University of Milan-Bicocca e-learning team (Paolo Ferri, Andrea Garavaglia, Livia Petti, Francesca Bossi). The LCMS has been customized to be used directly by young children and teachers for discussing and sharing knowledge with other schools and with parents.
6. On the basis of the results of previous phases, new operative and "blended" educational paths for teachers will be built and implemented.

RESEARCH RESULTS

We outline here some of the findings that emerge from our video ethno-dialogical observation. The use of "video-ethnography" Tobin, Wu, and Davidson method, have permitted to create a "semiobjective" video material. In order to better understand the way young child interact in the very first years with computers, and in order to make more affective the results of focus group with teachers and parents. In our view the emergent phenomena, we observed, in the approach of young children (K3/6) to computer:

- New paths and new ways for cooperative learning, in the peer-to-peer relationship in the use of computers and ICT
- The adoption by the children of a "cognitive multitasking style" in using computer and an intense use of video and musical code (Veen, 2003; Veen & Vrakking, 2006)
- Multiple intelligence at work (Gardner, 1993) through multimedia devices: emphasis on video and graphical and musical intelligence. Exit from "only alphabetic" paradigm in learning and teaching (Bolter & Grusin, 1999)
- New peer to peer interaction (mostly written) and multimedia communication, less deep personal communication, as results from the observation of the children working in the Bambino Autore Project www.bambinoautore.it
- A tricky use of "grasshopper mind" (Papert, 1994): Bite and run—Distractattention.
- A new mediated way to "construct" and share the world both individually and socially through media (user generated content, mobile phone video, sms, vsm—(Goodmann, 1978).

We can now better understand how the use of ICT changes the cognitive skills of children and young people in many ways:

- Stressing a multitasking use of media. Our research parents and teachers focus group strongly agree with this idea. Their children use a multitasking approach in gaming, playing and learning. Sometimes they feel this difference with fear they are not able to act in this way.
- Promoting cooperative learning. This is the way children adopt also when they are very young, 2-6 years, in approaching computers and ICT. As our observation demonstrates, they very rarely stay alone when they are using a computer al school
- Learning by doing the ICT and with the ICT is strongly preferred by the children we observed. Emphasizing the need of metareflexion on practical experience lead by teachers.
- Online communication, especially instant messaging, text messaging, and so forth, are very spread pattern of ICT use (mobile phone instant messaging) also in the 6-10 range of age. In Italy (i.e., the context we analyzed) the use of mobile phones is a tool used by nearly all children both to communicate with peer (mostly in a written way - SMS-) and with parents (voice communication). Parents use mobile phone not only to communicate with children but also as control/care tool. Mobile phone, in Italy has become a mediated tool for parental care. In the school the mobile phone is forbidden and teachers are very concerned about the children use of such a technological tool. In the same way they are very concerned about video game and video user generated content.
- Children at home, as testified from our observation, learn from their parents to use a modeling style, at school this style is very rarely adopted by the teacher.
- In Italy, children form extraEuropean countries, use intensively ICT because ICT (Skype at the Internet café, e-mail, etc.) is useful to keep in touch with their parents. It can help their integration in school because they have an excellence skill to share with pairs and teachers.
- In our view children often dislike educational software because in their experience this software is worst designed and low budgeted than video games and commercial Websites on the Internet.

Other hints that come up from our qualitative research are reported below (they apply only to the Italian case):

- The digital native phenomenon (Prensky, 2001) (it is not clear if this concept is exactly similar to NML) appears relatively late. It starts with children born after the 1993, not earlier. This probably happens because of the gap between Italy and U.S. and Northern Europe in the spread of computers at home and in the school. The first serious government plan for new media introduction in the school in Italy was built up in 1996 (PSTD - plan for the development of instructional technology).
- The use of ICT is mostly a domestic phenomenon, the use in the school is rare and limited to only a few days per month. There's in fact a big divide between the family, the social appropriation of ICT and its use at school (both at primary and secondary levels).
- There is no specific formal teachers training on technology of education and new media education, except for the Indire PuntoEdu project. Unfortunately the technological culture is not an issue for the Italian scholastic system. And the children and young girls and boy use very rarely technology as creative and free tool for education.
- Gender issues are fundamental, particularly in the early childhood years. Teachers in primary school are mostly fifties born female (the "baby boomers" generation). They, as our focus group pointed out, learn technology mostly from the romantic partners. In the same way they perceive technology as male, mechanical, and alien. That's why they are very resistant to introduce ICT with kids and female world.
- Gender issues interact also with the way female "baby boomers" teachers (90%) use technology with kids. They are mostly scared that computers can transform kids into machines.
- From the point of view of educational innovation, we point out that it is not a technical issues but a cultural issue. In training teachers to new tech it is far more important to investigate which kind of prejudices they have on technology than train them about technological issues. Understanding and sharing the meaning of resistances and prejudice is very important for overcoming them.

CONCLUSION AND FURTHER DEVELOPMENT

We believe that new digital technologies may become a catalyst for the exchange and sharing of information among adults who care for young children; they can also contribute in promoting a new way for the overcoming of the "digital generational gap" (Papert, 2006) between children, teachers and parents and for the promotion of a new digital literacy and fluency in schools. Our research has already reached a number of its "medium term" goals, among which:

a. Supporting young children in exploring the multiple functions of these technologies and helping them to "protect" themselves from the "isolation" and the "communicational autism" that some e-learning methodologies, especially "instructionism" imply. To achieve this goal we outlined and projected a specific methodology of the coconstructive method of blended learning (in the classroom and on the LCMS). This method main guideline is based on the creation of situated, active, and child-centred, techno-learning paths.
b. Gaining a better understanding, trough video analysis and focus groups of teachers' and parents' "fears or concerns" about the cultural impact that new digital technologies may have
c. Developing a methodological approach which combines the sound theoretical grounding of the reflection on education and on "digital education and learning" with the importance of being aware of the ways in which children and adults approach these tools and react to their stimulation

The next steps of our research will involve:

a. Longitudinal examination and mapping of the evolution of the real and virtual learning communities we have promoted (beginners and advanced groups),
b. Disseminating these method in other contexts, like early childhood settings and primary schools,
c. Creating, with children and teachers of early childhood and primary schools, specific learning objects coherent with the approach of a situated and cocostructed use of technology. These learning objects will be open-source, strongly contextualized, and enriched by personal experiences
d. Mapping the tacit and unstructured knowledge that is now at work in our project. Due to time lack virtual communities do not have until now user-friendly tools for "knowledge management".

These tools should manage the problems of informative-documental management, providing virtual communities with the tools required to build clear and shared conceptual frameworks.

NOTES

This paper describes the design, the methodology and the key results of the research Children and Computer. Experience and Conceptual Frameworks (3-6). *The research, started in 2004, is supported by IBM Foundation Italy and University of Milan-Bicocca –* Dipartimento di Scienze Umane per la Formazione "Riccardo Massa". The research *team, led by Professor Susanna Mantovani, includes: Chiara Bove, Paolo Ferri, Valentina Garzia, Susanna Mantovani, Anna Poli, Donata Ripamonti, and Angelo Failla (IBM Foundation Italy), Morgana Stell (IBM Foundation Italy). The second part of the paper try to analize the result of the research*

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KEY TERMS

Computer: Computers are extremely versatile. In fact, they are *universal* information-processing machines. According to the Church-Turing thesis, a computer with a certain minimum threshold capability is in principle capable of performing the tasks of any other computer. Therefore, computers with capabilities ranging from those of a personal digital assistant to a supercomputer may all perform the same tasks, as long as time and memory capacity are not considered. Therefore, the same computer designs may be adapted for tasks ranging from processing company payrolls to controlling unmanned spaceflights. Due to technological advancement, modern electronic computers are exponentially more capable than those of preceding generations (a phenomenon partially described by Moore's Law).

Constructivism: Formalization of the theory of constructivism is generally attributed to Jean Piaget, who articulated mechanisms by which knowledge is internalized by learners. He suggested that through processes of accommodation and assimilation, individuals construct new knowledge from their experiences. Assimilation occurs when individuals' experiences are aligned with their internal representation of the world. They assimilate the new experience into an already existing framework. Accommodation is the process of reframing one's mental representation of the external world to fit new experiences. Accommodation can be understood as the mechanism by which failure leads to learning. In fact, there are many pedagogies that leverage constructivist theory. Most approaches that have grown from constructivism suggest that learning is accomplished best using a hands-on approach. Learners learn by experimentation, and not by being told what will happen. They are left to make their own inferences, discoveries and conclusions. It also emphasizes that learning is not an "all or nothing" process but that students learn the new information that is presented to them by building upon knowledge that they already possess. It is therefore important that teachers constantly assess the knowledge their students have gained to make sure that the students perceptions of the new knowledge are what the teacher had intended. Teachers will find that since the students build upon already existing knowledge, when they are called upon to retrieve the new information, they may make errors. It is known as reconstruction error when we fill in the gaps of our understanding with logical, though incorrect, thoughts. Teachers need to catch and try to correct these errors, though it is inevitable that some reconstruction error will continue to occur because of our innate retrieval limitations.

Digital Divide: The digital divide is the gap between those with regular, effective access to digital technologies and those without. The digital divide is related to social inclusion and equality of opportunity. It is seen as a social/political problem and has become increasingly relevant as the industrialized nations have become more dependent on digital technologies in their democratic and economic processes. Larry Irving, a former United States Assistant Secretary of Commerce and technology adviser to the Clinton Administration, made the term digital divide popular in a series of reports in the mid 1990's. The digital divide results from the socioeconomic differences between communities that in turn affects their access to digital information mainly but not exclusively through the Internet. Broadly speaking, the difference is not necessarily determined by the size or depth of the user group. Any digital media that different segments of society can use, can become the subject of a digital divide.

Early Childhood Studies: The early years are regarded as being the crucial time in a child's learning and development and this course reflects the growing interest now taken by educationalists in this field. At what age should children start school? What role do families play in providing the foundations for successful learning? What sort of nursery education should we be providing? How can play be used in education? Early childhood studies draws on a range of disciplines including psychology, health care, educational studies and sociology in order to understand this formative period of our lives. If you are interested in young children and how they learn and grow, then this course will enable you to explore this fascinating stage of human development. It will also give you the professional and academic skills as well as the hands-on experience you need to work with children. Early childhood studies is offered as part of a three-year combined honours degree so you study it alongside one other subject. It combines particularly well with other courses in the institute such as: education and human development; communication, media, and culture; philosophy; religion; sport and coaching studies or performing arts.

Alternatively it can be combined with any of one of over 60 other subjects such as psychology, history, or sociology.

Education: Education is the process by which an individual is encouraged and enabled to fully develop his or her innate potential; it may also serve the purpose of equipping the individual with what is necessary to be a productive member of society. Through teaching and learning the individual acquires and develops knowledge, beliefs, and skills. It is widely accepted that the process of education begins at birth and continues throughout life. Some believe that education begins even earlier than this, as evidenced by some parents' playing music or reading to the baby in the hope it will influence the child's development. *Education* is often used to refer to formal education. However, it covers a range of experiences, from formal learning to the building of understanding and knowledge through day to day experiences. Ultimately, all that we experience serves as a form of education. Individuals receive informal education from a variety of sources. Family members, peers, books and mass media have a strong influence on the informal education of the individual.

Technology: Despite its cultural pervasiveness, technology is an elusive concept. It can refer to material objects, such as machines, hardware or utensils, but it can also encompass broader themes, such as systems, methods of organization, and techniques. It is an ever-evolving body of knowledge that both shapes and is shaped by societies. The proliferation of new technologies, such as computers, has left some people believing that technology is a determinant force in society, or in other words, that it is an autonomous agent that drives change. It would be more appropriate to discard this reductionist approach, and regard technology as one component of a multi-faceted cultural matrix, which includes social, political, historical, and economic factors that work together to spawn change. The word technology originates in the Greek words *technologia* (τεχνολογία), *techne* (τέχνη, which means "craft"), and *logia* (λογία, which is "saying" or "ordering", in the sense of arranging).

Classics Teaching Through ICT Experience to ICT Manual for Classics Teachers

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INTRODUCTION

Some European Classics Teachers, moved by the same passion for Classics and together for Information and Communication Technology so that from long ago used it on teaching Classic subjects in secondary high schools, decided to assemble their own long experience in this field to disseminate Information and Communication Technology for Classics world in Europe and their particular aim has been to demonstrate the importance to insert it in classrooms work about Latin, Ancient Greek & Classic Civilizations. So in 2003 was born CIRCE Project (www.circe.eu): Classics and ICT Resource Course for Europe (of which CIRCE is the acronym); it is the result of 6 European countries partners (Belgium, Denmark, France, Greece, Italy and United Kingdom) that met and agreed to create, through three years' work, from 2003 to 2006, 2 important products: (a) A multilingual Website (www.circe.eu) (b) A manual, translated and printed in different European languages.

BACKGROUND

What is CIRCE? It is the research of the intersection between Information and Communication Technology and Latin & Ancient Greek or Classic Civilizations, fruit of year by year studies in ICT (there is a very long list of authors) and experimentations in schools all over Europe and it could give an answer to many questions, from pedagogical to technical issues, as teachers directly involved could implement step by step their daily work with classrooms. ICT revolution did get all over in our life, in the educational world too the impact has been very important (Salomon & Perkins, 1991), transforming methodologies in teaching and approaches in learning. Computers did create a new interaction system between educational partners, teachers and learners (Jonassen, 1995). So traditional educational systems all over Europe have been changed and innovated in recent years so quickly through Information and Communication Technology (Calvani, 2000). The life of Classic Languages & Cultures has been unchanged a very long time because there were matters left too long apart from technological progress and the problem was due to the secular unchanged transmission of contents, generation by generation, going exclusively round the paper books through three phases of work: reading, translating, and studying to memory. In this chapter, we cannot write all of the history of ICT development in educational world of course, but we will cite some representative articles.

Morgan (1999) in Derby Grammar School did implement ICT in his teacher work about Ancient Greek. His purpose was to stimulate and improve students' learning. This experience such as other CIRCE partners works and studies want to show what and how in Classics teaching too Information and Communication Technology can completely be used by all Classics Teachers. Midoro, Olimpo, and Persico (1996) did show in their studies the important evolution of teacher role and student profile in this scenario, as perfectly described and analyzed by many of other ICT and Didactics specialists, such as Calvani (1994, 1995, 1998), Kumar and Smart (2004), Taylor (1980), Varani (2002), and Varisco (1998), citing some of them.

After we have considered these details, we hope that CIRCE Manual (4 Chapters, 109 pages) and CIRCE Web site can be time by time a "compendium" of all theories and practices in ICT & classics.

MAIN FOCUS OF THE CHAPTER

What are the Most Important Points of CIRCE?

a. CIRCE Web site (www.circe.eu) offers online all Manual pages and extra materials, useful resources to teachers, as font for Ancient Greek, short articles about Classics Teaching in Europe countries, lessons plans, software by country and other WEB resources in Europe, an important Images Gallery, and so forth.

b. CIRCE Manual was completed in November 2005 and printed in May 2006. The 1st manual entirely dedicated to apply ICT on Classics; it represents the most demanding work of all partners together, a common effort in selecting best practices through specific Classics & ICT cases study, comparing different educational systems, evaluating concrete lessons plans, creating common resources, organizing training courses (national and transnational) and discussing for a long time about pedagogical and technical issues, especially what new skills the teachers must have in new educational scenarios, as analyzed by Galliani & Manfredi (2001). The teachers who experimented Information and Communication Technology on teaching Classics subjects noted a lot of problems, from times, instruments, software and hardware to content management and new role for teachers: all these details have been presented in CIRCE products that would be a fine support for Classics teachers who are beginners in Information and Communication Technology, an interesting suggestion for all teachers in medium or advanced level and a good help for all people more or less involved in Classics world that are open to new technologies. All these points can show as well that Information and Communication Technology has modified an educational specific context as Classics Matters (in Figure 1 a reproduction of CIRCE logo is given).

Figure 1. CIRCE logo

FUTURE TRENDS

What can CIRCE Offer in the Future to Teachers and Students?

CIRCE Manual is the start up point but especially CIRCE Website, as a dynamic site, would be in future a "central site" on disseminating Information and Communication Technology applied to Classics World, all over the countries, a further testimony of what and how Information and Communication Technology can do in teaching and learning mode for Classics target.

Transnational Courses such as National Courses will represent the total realization of CIRCE aims.

CONCLUSION

CIRCE works represent how Information and Communication Technology year by year entered in all sectors of our life and educational world too can be really improved especially applying new technologies in matters and fields where traditional ways were for a long time the only one possible scenario, as happened for Classics Languages & Culture.

CIRCE presentes a lot of resources and in the future will continue to offer new panorama and new scenarios in which ICT can be inserted.

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KEY TERMS

Best Practice: The selection of real experiences that CIRCE considered as a good sample in this field (cfr. CIRCE Manual).

CIRCE: Acronym for Classics and ICT Resource Course for Europe (www.circe.eu).

Innovative Educational Methodologies: CIRCE offers a big panorama of many possibilities to apply as innovative methodologies for teachers/students (cfr. CIRCE Manual).

Integration of ICT: The most important issue noted by teachers in all ICT discussions, that is, how can we integrate or insert correctly and in useful way ICT in our work? (cfr. CIRCE Manual).

Lesson Plans: Specific didactic units in which all CIRCE teachers used ICT on Classics (cfr. CIRCE Website).

New Teacher Role: New profile of teachers who decided to use ICT in their classroom work or in computer room (cfr. CIRCE Manual).

Collaborative Knowledge Management (CKM) and Enterprise Knowledge Management

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INTRODUCTION

This article will describe the background, basic infrastructure, and future trends of collaborative knowledge management (CKM) and enterprise knowledge management (KM) systems. CKM is about capturing the information that is in people's heads and sharing it in a collaborative manner (e.g., an open, application-independent framework that allows all to have access to it) across the enterprise. In order to take advantage of the knowledge that exists in organizations, an authoring process must be undertaken that categorizes and places important information into a shared resource (often referred to as a "knowledge repository") that can be assessed by all relevant stakeholders. Collaboration should be across departments, various types of employees, and different types of projects within the enterprise. Some of the important topic areas that will be discussed in this article are the focus on the benefits of CKM and enterprise KM systems and the recent attempts to define the return-on-investment (ROI) of sharing knowledge across organizations.

BACKGROUND

Knowledge is defined by the *Encarta Dictionary* as "general awareness or possession of information, facts, ideas, truths, or principles." KM is defined in this article as "the collection of processes that govern the creation, dissemination, and utilization of knowledge" (Newman, 2005). The importance of KM is that it is the key to deriving productivity from Drucker's (1959) archetypal "knowledge worker" (defined as a person who can make a living based on the knowledge in her head). If a "knowledge worker" can have access to key information, this can potentially lead to an increase in individual innovation, productivity, and, ultimately, the company's profitability.

According to Laise, Migliarese, and Verteramo (2005):

Knowledge workers represent people who constantly enrich and enhance their knowledge and skills to create value. Knowledge workers can use their competence to create value by transferring and converting knowledge to create better processes, new designs for products, licenses, trademarks, patents, customer relationships, brand awareness, reputation and consumer satisfaction and so on. (p. 125)

The problem is, according to Plewes (2004), that:

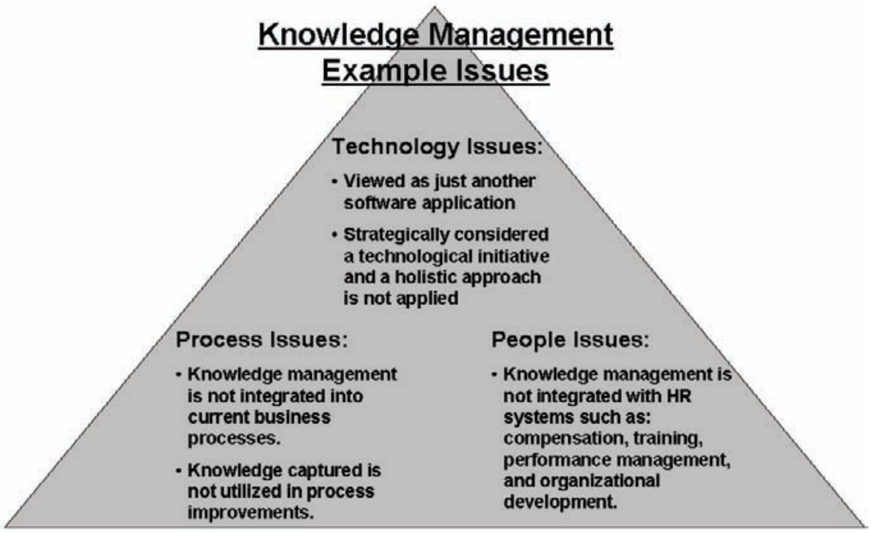
companies have long tried to both make sense of all the information that they have collectively accumulated over time and try to capture the business-critical information that resides in the heads of their key employees. Knowledge management promised to provide the wherewithal for capturing and disseminating this business-critical information.

However, many companies have been unable to convert upon the promise of KM because of various technology, process, or people issues (see Figure 1).

These issues (most of which can be solved by good strategic planning and project management) can lead to ineffective KM systems. In fact, Tanner (2004) suggests that one third of major enterprise KM solutions do not meet expectations. Even when effective, theorists believe that the real payoff for KM comes when it is shared across the organization in a collaborative manner. Making the information available to all relevant stakeholders can lead to increased innovation and learning across the organization.

Collaborative knowledge management is about capturing the information that is in people's heads and sharing it in a collaborative manner (e.g., an open, application-independent framework that allows all to have access to it). In order to make use of the knowledge

Figure 1. Some common issues organizations have while implementing knowledge management systems



that exists in organizations, an authoring process (also referred to the content management process) must be undertaken that categorizes and places important information into a shared resource (often referred to as a knowledge repository) that can be assessed by all relevant stakeholders. According to Plewes (2004), CKM differs from "navigational knowledge management," which is more focused on trying to glean knowledge (typically through using search tools) from the information that companies have collected.

Collaboration should be across departments, various types of employees, and different types of projects. An effective CKM system should have access points across the entire organization (Dove, 1999) similar to a matrix structure (which leads to some interesting system security and access/platform issues). One of the potential difficulties that some authors see in CKM is that knowledge does not exist in a vacuum but comes loaded with various sociocultural meanings as well. In an article entitled "Knowledge Management, Response Ability, and the Agile Enterprise," Dove describes the following situation:

Think of an American product development manager receiving a Chinese-language email message explaining a product innovation methodology rooted in the Taoist teachings of Lao-Tse—(even though) it was translated perfectly ... cognition is shaped by culture in general and language in particular. Think about it—and you'll think in words—and only those that your socio-cultural background gives meaning to. ... Now think about a culturally diverse, or even global, corporation—and its need to speed up the acquisition and mobilization of knowledge. (p. 12)

An organization cannot solve this problem by eliminating cultural diversity because, as Dove points out, "that would impair the important innovation potential" (p. 12). So, as new knowledge is added into the repository, the authoring tools and processes must find a way to quickly and effectively transfer it into a format that can be utilized by multiple people within the organization. This authoring process, if effective, will create a common language of knowledge or a "collaborative culture" (in the words of Dove, 1999). This theoretically should increase the ability to collaborate together across the organization and increase the amount of common organizational knowledge (potentially increasing the overall corporate IQ). This common knowledge shared in a collaborative manner across the organization should lead to an increase in the competencies (e.g., knowledge, skills, and abilities) of the individual members of the firm. However, managing these human assets is an area that is typically outside the purview of CKM.

Within an enterprise (also called organization or firm), this common knowledge becomes a cognitive system, just like in any living system, that helps the enterprise to be able to generate effective behaviors (could be to help the organization thrive or survive) in any given situation. This is described by Laise, Migliarese, and Verteramo (2005) as "knowing is effective (i.e., coordinated and 'successful') action." Therefore, managing the knowledge is a very important (and very difficult) function within an enterprise. Some of the difficulties enterprises typically have are keeping the information secure and accessing the knowledge from various geographic locations, and across various types of technologies and equipment (e.g., PCs, PDAs, cellular ohones, etc.). Thus, the growth of Web-based KM systems linked or accessed through intranets (with encryption security) has been a trend for many years now. Kittmer (2005) in an article for *KM World* states that the best organizational intranet should be:

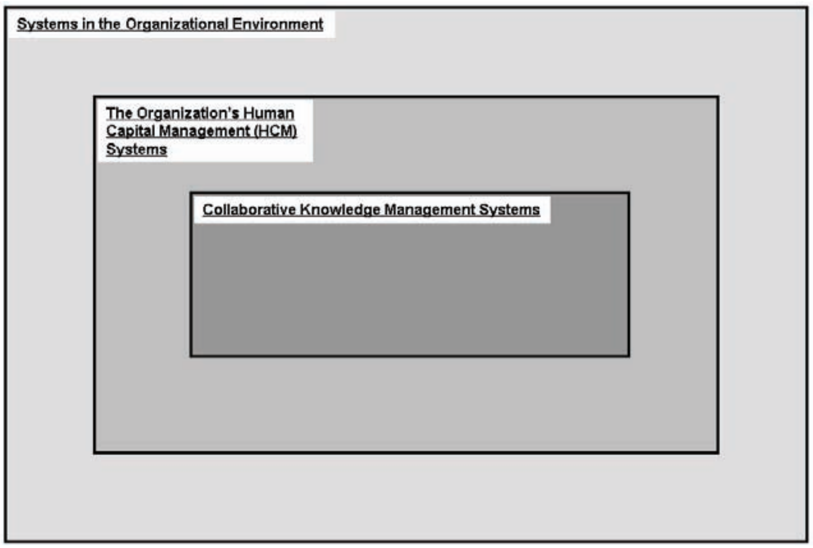
A dynamic site based on portal software. … More personalization is possible, offering a distinct and useful view of content and applications to individual employees or groups of employees. You can configure the software to deliver information and application access via mobile devices, or to run multiple sites serving multiple audiences. Portal software, therefore, provides a platform that can serve you well in the future. (p. 1)

FUTURE TRENDS

In the future, there will be more integration between CKM and human capital management (HCM) systems that track the intellectual capital within the enterprise. An example model of what this integration might look like, with the CKM infrastructure embedded within the HCM infrastructure and both embedded within the organizational environment, can be found in Figure 2. Conceptually, this illustrates that HCM is an aspect of the overall organizational environment, and CKM is an aspect of the HCM system (see Vequist & Teachout, 2006, for a review of the integration of these two concepts). This is because knowledge is the creation of employees that have various competencies and by managing (growing and developing) these competencies in the organization (HCM), the organization creates knowledge which should be managed (CKM). The technical infrastructure of the organization should reflect this emphasis on competencies and be designed to assist management in tracking both the human capital and the knowledge that exists within the organization.

In the future, both the CKM and HCM systems will interact with other systems within the organization environment. Some examples of these systems are (these are also displayed graphically in Figure 3):

Figure 2. Model of systems involved in collaborative knowledge management



I. Administrative Systems:

A. Enterprise Resource Planning (ERP) Systems (SAP, PeopleSoft, J.D. Edwards, etc.)
B. Human Resources Information Systems (HRIS) (Oracle, STAR, etc.)
C. Inventory/Supply Chain Management (SCM) Systems

II. Communication Systems:

A. E-Mail Systems (Outlook, Lotus, gMail, etc.)
B. Discussion Boards/Blogs
C. E-Rooms/Shared Network Drives

III. Sales/Data Systems:

A. Customer Relationship Management (CRM) Systems (Siebel, SAP, Oracle, etc.)
B. Data Warehousing (DW)/Predictive Analytic Systems (Oracle, SAS, SPSS, etc.)
C. Master Data Unit/Data Integrity/Security Systems

IV. Production Systems:

A. Office Software (Office, Star Office, etc.)
B. Computer Aided Design (CAD)/Computer Aided Manufacturing (CAM) Systems
C. Micro-electronic Manufacturing (MEM)/MES Systems

All of these systems can help with the effectiveness of a CKM implementation. In an article regarding knowledge portals (Smith, 2001), it suggests that:

Simple collaborative systems such as discussion groups, voting, questionnaires, and on-line chat groups are becoming standard features of CKM and portal software systems. Combined with knowledge sharing capabilities, these systems are tremendously powerful. Interestingly, a discussion group can be a powerful device for cutting across organizational boundaries and information silos, in that contributions can literally come from anywhere within the organization. Importantly, they can tap into sources of knowledge that otherwise remain hidden behind formalized roles and responsibilities, for example, experience from previous employment. (p. 23)

In the future, it is expected that more sophisticated forms of collaboration will be introduced to support CKM systems (e.g., telephone and video conferencing systems, shared screen technologies that augment audio

Figure 3. Drilldown of systems involved in collaborative knowledge management

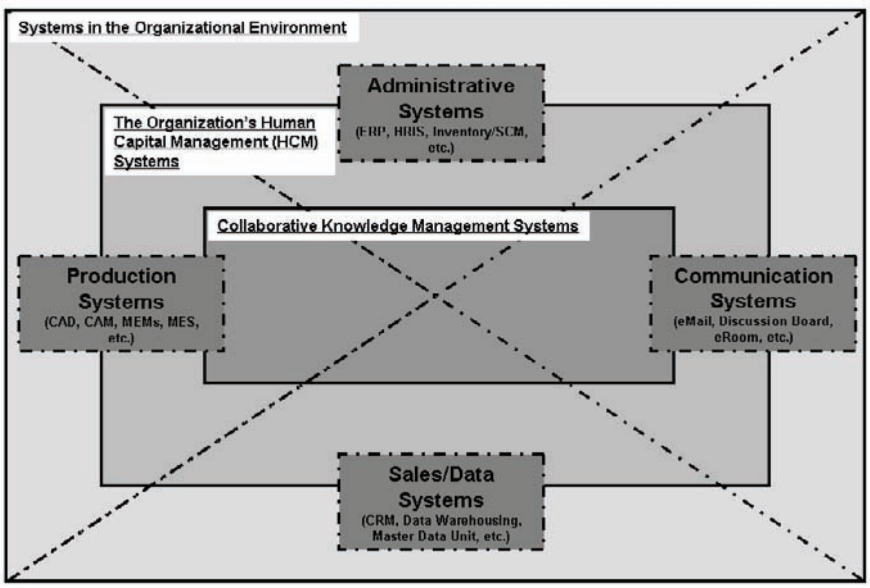
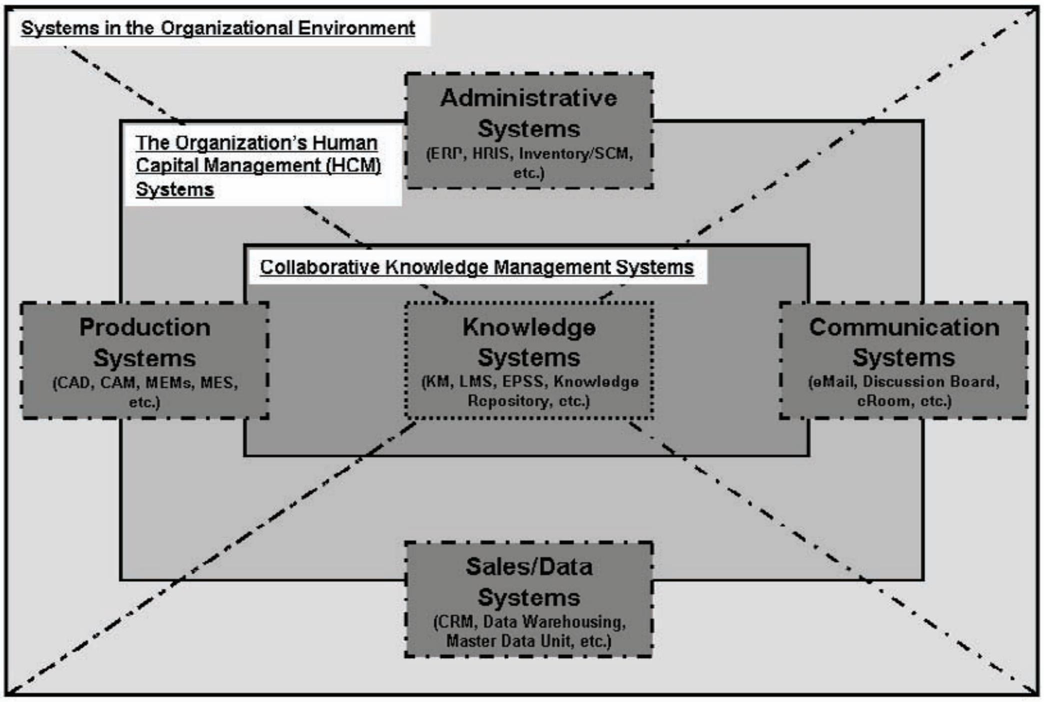


Figure 4. Knowledge systems and their place in the model



and video connections and capturing/recording of screen images). In addition, there can be more integration between CRM systems (what customers think about new products), SCM systems (how many new products are being sold), CAD systems (suggestions of product improvements), and so forth. Also, in the future, CKM systems will "gradually support more and more of the natural interactions between individuals and integrate this knowledge with other forms of information that are more easily captured" (Smith, 2001, p. 24). This system integration will bring together "knowledge, information and data from potentially disparate sources, and present it to the user in a comprehensive fashion" (Smith, 2001, p. 24).

Systems that typically have been at the heart of a CKM system are true KM systems, learning management systems (LMS), electronic performance support systems (EPSS) and knowledge databases or repositories. In many examples, there will be:

a variety of databases, document repositories and corporate applications that will need to be integrated to form the holistic view. Databases and documents stores are ideally integrated through an underpinning content management system. The architecture should be such that content can be accessed from distributed sources more or less as if they all came from a single data store. (Smith, 2001, p. 24)

In order to complete the future-based model, KM-specific systems are included in the CKM area which can be seen in Figure 4.

Integration with applications from across the organization will become increasingly necessary for CKM systems to achieve the potential that many have dreamed for them. The following example shows the importance of complete integration across a variety of systems:

Email conversations are now commonplace in a modern office environment, and significant information exchange and decision making takes place via this medium. Unfortunately, however, each individual is typically responsible for filing and extracting any valuable information for later use, and at best, this takes the form of a simple folder for each project or topic. In addition, e-mail conversations can take place in parallel to, for example, discussion group threads *on the same subject. Unless an individual takes the trouble to record an e-mail conversation in a discussion thread, then that conversation can be lost and certainly bypass those that were not on the mailing list.* (Smith, 2001, p. 24)

This example shows how CKM systems really need to be integrated into and with other office and corporate applications. Currently, IS/IT departments typically buy CKM and HCM systems separately from each other. In fact, many of the vendors do not offer integrated systems but offer separate applications that offer a narrow choice of solutions to organizations. Most likely, in the future, CKM will be part of a seamless working environment for individual employees who can have relevant information literally at their fingertips (Smith, 2001). This in time builds up the competencies that exist within the organization (organizational learning). This increase in competence should be tracked and utilized through the various systems that affect the HCM in the organization. Thus, the integration between CKM and HCM becomes strategically important to the organization of the future.

In a perfectly integrated environment, an organization would share data from the sales/design/manufacturing process across the employee population; this would lead to an increase in effectiveness and innovation, which in turn would lead to increased organizational competence. This competence should be developed and shared across the employee population (through various applications and/or media).

CONCLUSION

In the integrated environment mentioned above, the best type of access point for an integrated CKM and HCM application would be a Web-based portal. This portal could be accessed by various types of employees for a variety of purposes such as accessing/sharing information, training and development, and job placement/succession planning. Some technical requirements that an organization would need to research in order to establish an integrated CKM/HCM portal would be:

- Standards based
- Scalable
- Robust
- Low-cost
- Distributed
- Portable and Platform-Independent
- Multi-Tier Architecture
- Heterogeneous System Environment
- Secure
- Legacy System Support
- User Centric (Hayden, 2004)

An example scenario of what this future-based integrated application might look like follows:

Ms. Brown, an engineer in Dallas, is selected by executive management of XYZ Corporation to design a new product because her skill set and experience (as pulled from the HCM Web-based system) meets the needs of the project team. She utilizes best practices/lessons learned in new product design that were developed by Mr. Smith, a legendary engineer (who was based in Seattle but passed away several years ago; however, his ideas are kept alive in a Web-based CKM system that has various knowledge objects, such as documents, audio, and video clips), from his time at the company. These new designs are sent to Mr. Sun, a manager of the production facilities in Beijing, who was selected to manage this product based on his success on similar projects (found in the HCM system). He runs into some issues about materials that vendors provide (they do not meet engineering requirements), so he taps into the CKM system to find out how other managers have handled these issues. As he searches the system about this issue, both he and Ms. Brown are automatically enrolled into a Web-based training (WBT) program (about incorporating vendors in product design) which sends them a link, so they can access it just-in-time (JIT). Upon conclusion of both the training program and the product development, the HCM system updates Ms. Brown and Mr. Sun's profiles to reflect their new skill sets/experiences and then captures the best practices/lessons learned from the project into the CKM system (Vequist & Teachout, 2006). This example shows the potential power of an integrated Web-based system and its potential impact.

In summary, this article has introduced you to a future-based conceptual systems model that depicts several systems in the organization and how they relate to both HCM and CKM. The reason it is important to analyze and design integrated HCM and CKM systems is that it could ultimately lead to a companies' ability to:

- Remain competitive;
- Adapt to a rapidly changing environment;
- Be able to innovate;
- Respond to the demands of e-business;
- Fully capitalize and develop its people; and
- Support effective relationships with suppliers, partners, and customers (Smith, 2001).

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KEY TERMS

Collaborative Knowledge Management (CKM): This is a system to capture the information that is in people's heads and share it in a collaborative manner. In order to make use of the knowledge that exists in organizations, an authoring process must be undertaken that categorizes and places important information into a shared resource (often referred to as a "knowledge repository") that can be assessed by all relevant stakeholders.

Customer Relationship Management (CRM): This is a software solution that helps enterprise businesses manage customer relationships. CRM systems are databases that may contain detailed customer information about customers so they can be matched with products, service requirements, and so forth.

Electronic Performance Support Systems (EPSS): These systems support a worker so that they will be more successful and productive in their work. It can be any type of electronic system that supports workers with flows of data and information. These systems are very important in the new age of work because workers have become inundated with data and information, and it is imperative that they learn how to organize and consolidate it quickly and accurately. The payback for EPSS lies in its ability to adapt, change, and evolve to meet the changing needs of workers who utilize these systems.

Human Capital Management (HCM): This refers to the management of the human capital or competencies that exist within the organization. Just as in KM, HCM is a method that if the assets (competencies residing within employees) are not managed and utilized within the organization, then the organization will not derive the competitive advantages they offer.

Knowledge Management (KM): The process by which an enterprise consciously and comprehensively gathers, organizes, shares, and analyzes its knowledge to further its aims. This knowledge is usually gathered and stored in a knowledge repository.

Learning Management Systems (LMS): This is a software system that tracks employee training and possibly competencies. Typically, a LMS will track individual worker progress, record scores of quizzes and tests within an online learning program, and track course completions. May be integrated with a Human Resources Information System (HRIS).

Web-Based Training (WBT): This is a form of computer-based education or training where the training material resides on the Internet and is accessible using a Web browser. This form of training typically incorporates multiple types of media elements into the content including text, graphics, animation, audio, and video. May be facilitated by a trainer or be in a self-directed, asynchronous format.

Comparison of Technologies and Methodologies in the E-Learning EXPO Experience

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INTRODUCTION

Making an effective presentation of the scientific activity that took place in the context of the E-Learning Expo, through a significant analysis, is a welcome but complex task.

The E-Learning EXPO is an experience that has occupied CARID (University Centre for Research, Teaching Innovation and Distance Learning) University of Ferrara, Italy for the last two years in the creation of an environment in which demand and supply, theory and practice of e-learning could successfully meet up (Frignani, Galliani, Giacomantonio, 2005; Poletti, 2006).

The intention of CARID, as creator and scientific director of the event, was not merely to provide a showcase, but an event packed with conferences and debates aiming at taking stock of the state of the art, not only as regards methodological reflection on e-learning, but also as regards the application of e-learning as a method to be used in a variety of public and private sectors, ranging from school and university to professional and corporate training, from enterprises to banks, from environment to education, from the health service to public administration, as far as e-government and e-democracy.

But why the term "welcome but complex", which would appear to express a dual state of mind vis-à-vis this experience, the growth and development of which Ferrara has witnessed over the last two years?

"Welcome" because the level of scientific contributions presented at the conferences, and the quality of the presentations made at the plenary sessions—which saw representatives of the worlds of academia and production coming to grips with one another—have grown, both as regards quantity and quality, attesting to the path that has been undertaken as a result of profound reflection, a path along which we continue to advance, deepening our knowledge still further in an attempt to provide increasingly more concrete and efficacious applications on the topic of e-learning.

"Complex" because it is impossible to measure the complexity which has undoubtedly been generated by the state of transition which e-learning is currently experiencing.

Indeed, e-learning seems to be going through an almost adolescent growth crisis in which, subsequent to the initial spontaneous and enthusiastic response accorded to it (or rather to the advent of multimediality and the Internet in the world of education) from traditional learning institutions (schools, universities, and vocational training bodies) and business environments alike, it has now become necessary to make of this tool something which is innovative but which, at the same time, has a distinct character—not an alternative tool but a synergic tool for use in the lifelong learning sector.

THEMES AND CONTEXTS

The EXPO experience has undoubtedly brought to the fore an interesting point which appears to be the key element of experiences of this type, that is, beyond the specific fields of application which have with e-learning overlapping areas involving greater or lesser shared areas, the main characteristics of which were highlighted at this conference, general attention seems to be focused on the method and consequent impact produced by e-learning—both from an organizational and from cultural standpoint—to a degree which is directly proportional to the extent to which this phenomenon has gained ground within the teaching systems.

In this sense, the words with which Professor Fredric Michael Litto, President of the Brazilian Association for Distance Learning opened his presentation on the

2005 edition of the event—"*students and the discovery of knowledge*"—are paradigmatic (Litto, 2005). He pointed out how technology and e-learning are the precursors of a "*totally new reality*" which cannot be divorced from technology, virtual communities and multimedia knowledge, but must be considered in an intercultural approach.

A concept, this, which is not applicable exclusively to the world of education and student training but has the potential to become a new way of structuring and sharing knowledge and the culture from which such knowledge derives.

The presentation given by Jeffrey Merriman of MIT (Massachusetts Institute of Technology) and Project Manager of OKI (Open Knowledge Initiative) was along the same lines. In a similar context he proposed a paper with a title which highlights the perspective that this experience was intended to offer: "*Open Source or Vendor Driver Solutions? Integrating the best of breed of both worlds via Standards based Open Service Architectures.*"

The main consideration on which the EXPO experience focused, a consideration which seems, moreover, inevitable for the growth and integration of e-Learning in learning and teaching processes, derives from the concept of interoperability and structuring of knowledge as a methodology for encouraging a sharing culture, as this is the added value which e-learning can and must offer to the society of knowledge (Poletti, 2006).

A consideration of such proportions leads to the perception that e-learning is about to experience a period in which the enthusiasm typical of youth and the initial phases of any innovation should not be abandoned but upheld through contemplation of its own role and the development of its own strategies which increasingly portray it as a structural, and not a substitutive, element in the learning processes.

And here we have the complexity factor that emerges in the course of this consideration: e-learning seems to present new functions and new possibilities in all of the environments in which it is incorporated, at the same time, it cannot be structurally incorporated and interact with an environment, be it a learning or a business environment, without changing and giving rise to new perspectives in the setting in which it is integrated.

It is clear from the considerations that the presentations and meetings which EXPO hosted and for which it acted as a sounding board, that e-learning is coming closer to and interacting more and more with *knowledge management,* indeed the overlapping of these two areas is such that is difficult to draw a clear separating line between them.

It may be clearly deduced from the speakers' presentations that, in view of the fact that this methodology concentrates attention more heavily on the concept of learning as opposed to teaching, the need to structure knowledge cannot be disregarded to enable profitable use through the semantically and ontologically valid construction of individual if not personalised learning paths.

The suggestions that emerge from a reflection on the topics covered in the course of this event are many and varied, and they are determined by factors whose importance is further heightened by the fact that they are transversal to the areas in question, that is, that they are to be found in worlds that, for reasons related to both culture and tradition, appear to be distant.

The development process that e-learning is undergoing is an explosive factor both in the world of education and in the professional training sector, as in the university and lifelong education. The same applies to the world of business and finance, public administration, the health sector and the world of sport all of which are witnessing the development of projects of undeniable value, attesting to the growth of an online and distance learning culture.

The duality between technology and methodology seems to be the driving guideline of research on e-learning. EXPO has highlighted the need for the tools typically used in e-learning to be made the subject of methodological reflection.

The first tool which, in this context, should be made the subject of reflection is the e-learning platform inasmuch as it embodies this constant duality between technology and methodology, a duality that gives rise to a question around which a debate evolves, the purpose of such debate being to define which type of education and which teaching methodology is being developed, which Learning Objects and for what learning purpose.

E-learning, and this EXPO experience is the demonstrative proof, must get methodologists, technologists and communication experts working together in a virtuous circle.

CONSIDERATIONS AND PERSPECTIVES

The perspectives that this experience has unearthed are the fruit of a series of considerations relative to the various areas which, until now, have approached or integrated e-learning in their processes.

The first consideration regards the information society which must be sustained by the learning society, another challenge that is involving the educational system both at Italian and international levels. New technologies are increasing their degree of penetration in the educational system, with positive impact on teachers and students alike.

For this reason, efforts must be focused on the defining of an efficacious teaching method that takes technological developments into account but that also bases its criteria on the cognitive aspects of e-learning.

The computerising of the world of education and the vocational training sector requires planning skills with a view to utilising this technology in a structural fashion and as a support tool for the educational process. Learning and vocational training must be able to combine the traditional spheres of knowledge with the new technologies in order to contribute to the growth of the individual both from a cultural and from a professional point of view.

A second consideration springs from the observation of the systematic and integrated use of information and communication technologies (ICT) in training initiatives geared to support and develop learning processes.

As an immediate consequence of this state of affairs, it becomes necessary to exploit the concept and use of open and flexible learning, redefining space and time parameters, decisive factors in online and distance learning.

Thus the need to transfer from a teaching method based on subject knowledge to a teaching method focused on the social building of "life skills", through debate and practical communities, both real and virtual, in the online society.

For the university world, this means taking part directly in the production processes of the culture, and not just in its transmission to new generations.

The problem is no longer understanding whether university teaching should change, but how such change should come about and who will be the players in the process. The issue is no longer whether e-learning is useful to change, but what place it should occupy in learning and research.

A third consideration springs from worlds that appeared to be far-flung from e-learning and from the reflections inherent in the teaching/learning relationship.

In actual fact, the first to experiment these technologies and methodologies which, after various phases of refinement over time, have now come to be called e-learning, was the world of business. To this end, two apparently conflicting requirements forced entrepreneurs onto the road of experimentation, impelling them to adopt complex systems which did not always prove to live up to their expectations:

- The need for constant updating of human resources throughout their working life, also managing turnover situations, preserving the company's know-how, which is always the enterprises real capital;
- The need to guarantee the possibility of rapid, immediate training courses when confronted with a new process, new legislation, a reorganization of the company.

Lastly, although only chronologically speaking, the interest of the public administration offices in the technologies and methodologies of e-learning, which finds its main justification in the close instrumental and function connection between this particular subject and the processes of e-government, the dissemination and assimilation of which—both internal to institutional organizations and with regard to users—requires the support of a training activity necessarily characterised by the use of the Internet and asynchronous information transmission methods.

The technological affinities and functional interdependence between e-learning and e-government are clearly demonstrated in the development, integration, and normalization of e-government activities carried out in the context of various projects which have led to the design and testing of mixed e-learning/e-government/e-democracy systems.

EXPO was not just a workshop stimulating reflection and experimentation of e-learning, since the reflections made have resulted in the launching of a challenge: that the virtuous circle existing between methodologists, technologists and communication experts might become a system process. And EXPO is ready and willing to assess the effects and fruits emerging from this challenge in its next edition, which could become a leading observatory and test workshop for e-learning.

An observatory that permits the monitoring of the progress of e-learning not only on the basis of statistics or informative research but on the basis of the debate that those operating and researching in this field have initiated and the fruits of the reflections emerging from the same.

A workshop which does not limit itself to the comparison and testing of e-learning tools - from platforms to learning objects—but in which speculative thought may be effectively translated into concrete processes.

If until now EXPO has represented a step forward along the road of cultural dissemination which e-learning requires, and an efficacious vehicle for spreading the tools that make e-learning an important feature in our society of knowledge, it is still too early to say; we can nonetheless affirm that, on the basis of the considerations made so far, it has been an important junction in the road that e-learning is arduously but continuously tracing, both as regards education and technology, as well as production and business.

E-learning therefore emerges from this experience with the responsibility to express its creative potential which it can exploit more than any other to create an instrument of change.

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KEY TERMS

E-Democracy: Term which derives from the contraction of the two terms Electronic and Democracy; this term generally indicates the use of ICT (information and communication technologies) in the development of democratic processes. Due to the relatively brief history of the term (it was coined in the mid-1990s) and due to the environment to which it refers, a great deal of controversy still exists regarding its interpretation. In fact, it can mean the simple use of communication tools in democratic processes, the influence of the media in political life, or the tools that permit dialogue and participation in political life. In the http://e-democracy.org/ site, which was set up in 1994, we find the slogan "E-Democracy.Org—Building online public space in the heart of real democracy and community since 1994," which clearly demonstrates the meaning of this term.

E-Government: Term which derives from the contraction of the two terms electronic and government; this term generally indicates the use of ICT (information and communication technologies). Despite the fact that this term was coined only recently, the meaning of e-government has precise limits and refers to the computerization of public administration bodies. This computerization, which is accompanied, in most cases, by organizational changes uses ICT for the digital processing of documents. Also linked to the concept of e-government are the hopes and perspectives of simplification and interoperability of administrative procedures through the Internet.

E-Learning Platform: In general, a platform is a basic technology, on which other technologies are developed and if these technologies are equipped with tools that enable the creation of virtual learning environments, we can speak of e-learning platforms, inside of which the issuing of learning modules as well as the management and monitoring of skills. In this context we can speak of LMS (learning management systems) as application platforms that enable the provision of e-learning courses and LCMS (learning content management systems), platforms that directly manage the contents.

Interoperability: This term derives from the field of engineering and refers to the capacity of a technology or a tool to work in synergy with other technological systems, thereby obtaining additional services and possibilities. The various methods by means of which access may be gained to the Internet (from cell phone to computer) are examples of interoperability, fruit of the tendency to concentrate onto extremely advanced technologies a wide range of services and tools. The term interoperability has recently characterised the debate on Learning Objects (LO) where interoperability becomes the point of focus so that LOs created in different contexts can be re-used in a variety of ways and allow tracking of the student's learning path. Interoperability is linked to the use of protocols, one of the most important being SCORM (**S**hareable **C**ontent **O**bject **R**eference **M**odel), a dossier of technical specifications which enable, among other things, the exchange of e-learning contents independently of the platform.

Learning Objects (LO): This is undoubtedly one of the terms most widely used but one of the vaguest. There is a great deal of literature and agreement on the meaning of LOs but this agreement is accompanied by a great deal of shades of meaning. One of the most common definitions is that of David A. Wiley: "An LO is any digital resource that can be re-used to support learning." In general, it may be said that LOs are learning resources characterised by the fact that they are available (as metadata) through semantic research, reusable in various learning contexts, interoperable and modular, being aggregatable to form new LOs.

Lifelong Learning: A system based, of necessity, on Internet technologies and on the sharing of information with the aim of adjusting and improving professional skills. In particular, lifelong learning identifies a system that guarantees people a good level of adaptability to technological and organizational change. In general, lifelong learning is designed for those who having a working career that also involves professional refresher courses.

Computer Communication and ICT Attitude and Anxiety Among Higher Education Students

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INTRODUCTION

Computer communication (CC) otherwise known as information and communication technology (ICT) has altered the academic landscape in higher education. Computer communication is perhaps the most fundamental information and communication technology tool in use today. With pressures increasing on higher education institutions to find ways to "do more with less," CC/ICT is to maintain or improve the quality of services in higher education and at the same time, significantly reduce costs (Voss & Hadden, 2006). These days, the teaching and learning process has been altered by the convergence of several pedagogical developments aided by technological advancements. Advances in computer technology and the diffusion of personal computers, including software and network resources, have hastened the development, implementation and accomplishment of new and innovative teaching-learning strategies. As a result, instructors believe that a greater integration of ICTs in the instructional process tends to improve learning and better prepare students to effectively participate in the changing global work environment (Ololube, 2006b; Sam, Othman, & Nordin, 2005).

Computers and their associated products and processes have become core components of the higher education environment especially in the West. Students in advanced countries use computers as a means of communication and to complete the majority of their academic work (Green, 1998). As a result they have become a way of life for students in the West as opposed to students in higher education environments in most developing economies especially Africa. Nevertheless, the Republic of South African is more adept at integrating ICT for national development and within their educational sectors (Fielden, 1998; Lund, 1998) than other countries in Sub-Saharan Africa, including Nigeria (Ololube, 2006a). However, many students in this region's higher education find it very difficult to effectively use and make computer communication part of their every day lives.

Many students in Nigerian higher education find it very difficult to effectively integrate and diffuse computer products and processes into their academic activities that instigate information searches and attribution formulations. That is why this exploration measured and examined the ways in which CC/ICTs used in institutions are deemed acceptable and good for students' academic activities. We also recognize that the intimidating study environment has been construed to suggest a sense of weakness towards students' effective CC/ICT utilization. Overall, African CC/ICT readiness is poor in comparison to other economies, particularly Sub-Saharan Africa (SSA) with the exception of South Africa; on the other hand, North African countries fared better than those in SSA (Colle, 2005; Ifinedo, 2005). This study investigated students' attitudes and anxieties. It theoretically and empirically analyzed students' CC/ICT competencies and how they affect their educational/academic development. Data was elicited from students in two state universities in Nigeria.

This study integrates literature on computer anxiety and communication apprehension to determine their joint impact upon individual attitudes toward using computer communication (CC). This study introduces a new research domain and its application in identifying computer communication attitude and anxiety from a developing economy's perspective. This study to the best of my knowledge breaks academic ground because it is a domain that has been under-researched in Sub-Saharan Africa. This study moves forward a new framework that places CC/ICTs attitude and anxiety as an assemblage between the more general framework on computer communication attitude and anxiety with which we are familiar.

BACKGROUND AND PURPOSE TO THE STUDY

Computer mediated communication (CMC) is fast becoming part of our society and the use of information and communication technology (ICT) is becoming an integral part of education in many parts of the world (Kuntoro & Al-Hawamdeh, 2003; Sala, 2004). Africa is not left behind as ICT gradually finds its way into its educational systems (Brown, 2002; Darkwa & Eskow, 2000) despite chronic limitations brought about by economic disadvantages (Adesola, 1991). Exposure to the new medium of communication gives one the opportunity to acquire unlimited amounts of knowledge and a chance to communicate with others around the world. It is a fast way to create, send and consume new information and extends our mental capabilities and enhances our intellect. Yet there are many people who will be left behind in the technological quest for the faster and more efficient mode of communication. In addition, access to people, places and information is changing. A real change can be found in education. Despite income, school budgets or demographics soon all students will have access to information through the Internet. E-mail is taking the place of interoffice correspondence. Business is rapidly becoming computerized. Thus, students and workers will need to be comfortable with computers. As the academic and business environments continue to move forward in computer technology, the gap is widening for those people who experience computer anxiety (Orr, n.d).

Computer communication attitude and anxiety amongst higher education students is not new in research studies (Chua et al., 1999; Igbaria & Chakrbarti, 1990; Parasuraman & Igbaria, 1990). However, in integrating computers in higher education, researchers' results of computers having been integrated have proposed that positive attitudes toward computers and high computer self-efficacy and lower computer anxiety levels could be important factors in helping people learn computer skills and use computers. It is recognized, for example, that some college students felt confusion and a loss of personal control when they encountered technology. As many as one-third of the 14 million college students in the United States suffer from technophobia and implied that effectiveness in the use of computers in higher education might not be realized without research foundations and corresponding planning (Sam, Othman, & Nordin, 2005).

Fundamentally, education is a discipline like any other; it is a branch of human knowledge which is basically concerned with getting the young in the society prepared when they come of age (Ezewu, 1983). According to Gbamanja, (1989), education is a process which seeks to change the behavior of a learner. Overall, behaviorists view education as the process of changing the behavioral patterns of people. Behavior in this sense refers to the way we change the learner: his or her thinking, his or her feelings and his or her overt actions (Hergenhahn & Olson, 1997). Thus, education is the process by which society deliberately transmits its cultural heritage through schools, colleges, universities and other institutions (Gbemanja, 1989). In order to achieve the aforementioned purposes in education, information, and communication technology (ICT) one could argue is an essential ingredient that could help bring these gains and benefits to the fore. Practically, several researchers and commentators in the developed West admitted that problems abound in educational systems that ICT could help improve (Leidner & Jarvenpaa, 1993). Similar ICT problems would be expected to improve in the educational sector of many developing countries (Ololube, 2006a, 2006b).

CM/ICTs ATTITUDE AND ANXIETY

Available evidence shows that the digital divide is closing rapidly. During the last decade, millions of people especially in advanced countries have gained access to computers every year. Never in human history have there been so many people with access to computers, digital networks, and electronic communication technologies (Tuomi, 2000). The digital divide is the disparity in access to CM/ICTs that exists across certain demographic groups, discussion of which has been dominated by the gap between household access to computers and the Internet. Technically, the digital divide includes disparities in access to other related technologies as well. The term digital divide is used to refer to differing standards or imbalances between countries fully poised to reap the benefits of the information age and those that are unable to do so (Ifinedo, 2005; The Bridge Organization, 2001).

Literature on CM/ICTs attitude and anxiety offer conflicting ideas. Researchers (e.g., Agnetha Broos, 2005; Necessary & Parish, 1996), support the idea that increasing computer experience will decrease computer attitude and anxiety. Necessary and Parish (1996) found that college students with little or no computer experience have more anxiety than those students that have experience. Their study revealed that increased levels of computer experience and balance of weekly computer usage were both related to reduced levels of computer related anxiety.

Agnetha Broos (2005) found that the influence of computer experience works in different ways for males and females. Computer experience has a positive impact on decreasing computer anxiety for men, but a similar effect was not found for women. Glass and Knight (1988) argued that computer anxious students would become less anxious after an initial trauma period. By working through this fearful or frustrating stage students will gain experience, and thus reduce anxiety. It is believed that the major factor in computer attitude and anxiety is experience or rather inexperience. It is reasonable to assume that by increasing computer usage one would reduce anxiety. Yet, for those who are computer anxious this may prove to be difficult because there are varying degrees of anxiety and thus those who are highly anxious may completely avoid computers (Orr, n.d).

Contrarily, a criticism of the increasing use of computers emerges in the prediction that new teaching and learning technology would replace teachers, textbooks and even schools. Also, it was anticipated that the major method of learning by the year 2000 would involve for example, the use of modern technology like computers at all levels and in almost all subject areas (Borg, 1980). However, Crook (1994) found that this prediction does not appear to be true. Research (e.g., Cohen, 1987; Cuban, 1986) claims that the use of CM/ICT has to fit into the teachers' pedagogical view of teaching and learning, and if introduction of computers in schools is to be successful, one must start with the question of *why* they should be used and not *how* they should be used. However, it appears that CC/ICTs are looked upon as having a supplementary role in teaching-learning (Postholm et al., 2002). Cuban (1993) maintained that the "dominant cultural norms" with respect to learning, instruction and the nature of knowledge almost have a neutralizing effect on students' development. Postholm et al. (2002) on the other hand argued that some features of CC/ICTs must be seen as a potential that has to be implemented in contexts of learning.

It was found that there is a significant relationship between positive student attitudes and anxiety in the use, integration and diffusion of CM/ICTs amongst students. Vygotsky (1978) developed the concept of the zone of proximal development (ZPD) that has had a great effect on how we regard teachers' instruction and assessment in assisting students' level of development, which is reinforced by appropriate use of instructional materials. This concept is defined as: the distance between the actual developmental levels as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (p. 86). This means that instructors help students to perform tasks that they could not perform without guidance. Conversely, Wood, Bruner, and Ross (1976) use the term "scaffolding" to describe situations in which adults help students to carry out tasks or achieve goals that students could not reach without this help. They qualified their statement, however, by stating that instructors need to know about the performance qualities of their students in addition to understanding how to solve the task and before these goals can be achieved.

However, Tharp and Gallimore (1988) argue that instructors also need to know how to scaffold their students. They developed a theory of scaffolding methods, which is based on the premise that a good instructor is a master of simplification. It consists of assisting performance through the ZPD. The instructor, trainer, or educator must be confident and capable. Any anxiety on the instructor's part will have an effect on the students. Instructors need to remain calm and continue to encourage growth and exploration thereby encouraging confidence in students and keeping the computer experience enjoyable and fun. Students (especially those with prior negative experience) will need to build confidence in order to change their attitude. Instructors can help the student build self-confidence by providing successful experiences, especially in the early stages (Orr, n.d). Thus, effective teaching occurs when assistance is offered at points in the ZPD at which students require it which increases their positive attitude and lessens their anxiety about participating in academic activities (Ololube, 2006a).

RESEARCH METHODOLOGY AND FINDINGS

This study employed a survey research design to investigate final year undergraduate students' computer communication and ICTs attitudes and anxiety. The study also examined gender differentiations in relation to their attitudes and anxiety. One hundred and twelve (n = 112) students were randomly selected from two public universities in Nigeria. The students were aged between 21-30 years. A self-designed questionnaire that employed benchmarks from other similar studies in the West was used to collect data for this study. The instrument for data collection was made up of 20 items. The questionnaire had a four-point Likert scale response pattern. These were: Strongly Agree, Agree, Disagree, and Strongly Disagree and were weighted 4, 3, 2 and 1 respectively. The instrument had a reliability coefficient of 0.79. The data collected were analyzed using simple percentages of the Statistical Packages for Social Sciences (SPSS).

The research finding of this study indicates that higher education students' attitude and anxiety relates to the prior experience received during their early years of education. The data (64.2%) suggests a correlation between the unpleasantness of prior experience and their current attitude and anxiety toward computers. Evidence of this is the slow rate of use and integration of CC/ICTs amongst Nigerian higher education students. Students who have early access to CC/ICTs do not have computer phobia. In general, female students (51%) had more negative attitudes and anxiety towards CC/ICTs than did male students (49%). The results show a positive relationship between prior experience with CC/ICTs and attitude and anxiety. This is in line with the studies of Parasuraman and Igbaria, (1990), Agnetha Broos (2005) and Igbaria and Chakrbarti (1990). In all, the studies revealed that experience makes it easier to use and exhibit greater proficiency in using computers.

FUTURE TRENDS

The disadvantaged position of developing countries including those in Africa within a global economy with regard to technology and information resources is a situation that needs to be addressed adequately and promptly (Colle, 2005; Ifinedo, 2005). Efforts toward transferring technology to Sub-Saharan Africa are on the way. However, an overhaul of the technology transfer process may be necessary, requiring the acquisition of skills, knowledge, and abilities. In addition, making, repairing and adapting CC/ICTs are equally necessary. Sub-Saharan African countries should not just be a dumping ground for technology if they are to develop. These requirements may sound daunting especially in view of the human and material resources needed to successfully implement them.

Overwhelming dependency on government has often left higher education institutions ill equipped to manage this difficult situation. CC/ICTs capacity building through managing information systems and staff training are a thrust, but failure to address these issues may lead to goal displacement, and higher education institutions will be diverted from their primary role of teaching and research. However, the major limitation to this article, this study, and most of the studies consulted concerning CC/ICTs is that they are descriptive by nature.

Further examination of this subject matter will be in order using a carefully stratified national survey in investigating the themes and concepts used in this study. An in-depth and new perspective on CC/ICT students' attitudes and anxiety which not only take into consideration the unique characteristics of the variables used in this study, but other derivations, is very much recommended. Additionally, further studies could examine what specific measures are taken by developing countries to hasten the spread of CC/ICTs in their higher education system.

CONCLUDING REMARKS

This research study focuses on computer communication and information and the attitudes and anxiety toward communication technology amongst higher education students in a developing economy. It is believed that CC/ICTs constitute an important force in efforts to build an information technology society and to join the international community in meeting the millennium development goals. This study suggests that higher education the world over is a valuable actor in providing students some of the resources needed for their continued existence and development. This is significant because higher education institutions are enduring entities that ensure and create the diffusion of knowledge for national development. Society depends upon institutions of higher education for its growth and for the production of new knowledge, its transmission through education and training, and its dissemination through information and communication technologies.

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KEY TERMS

Computer Attitude: The predisposition of a person to respond positively or negatively towards computers. It affects everything the person does with the computer and in fact reflects what experience the user has and is hence a determining factor of the user's behavior towards computers. Additionally, the user's computer attitude provides the user with a framework within which to interpret the effect and the integration of computer in the user's life.

Computer Anxiety: The state of fear or tension of imminent contact with a computer that might be inconsistent with the actual danger presented to computer users. It has been associated with decreased use and worse, avoidance that can seriously affect some students' academic development. In addition, computer anxiety if left untreated leads to ICTs use and avoidance.

Computer Communication (CC): The process by which people create, exchange, and perceive information using networked communication classifications. It also includes nonnetworked computers that facilitate encoding, transmitting, and decoding information.

Computer Phobia: Associated with the anxiety about learning to use computers or not being able to learn to successfully use computers which is often used to basically mean avoidance or fear of learning the new skills required by increasing use of computers in the school or workplace.

Digital Divide: The term used to explain the divergences between people who have and people who do not have the skills, knowledge and abilities in addition to access and resources to use new CC/ICTs tools. This gap can exist between the educated and uneducated, privileged and underprivileged, between developed nations, developing nations, and those living in rural/urban areas.

Knowledge Society: An association of people that have similar interests, be they social, economic, political, cultural and so on and by making effective use of their collective knowledge in their areas of interest thereby contributing to further knowledge that will lead to national progress and global development.

Computer Simulations and Scientific Knowledge Construction

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INTRODUCTION

Information and communication technologies (ICTs) are increasingly expanded nowadays and undoubtedly constitute a vital component of our modern society influencing many aspects of our lives, such as administration, economy, culture, work environment, home life, and, most of all, education. In particular, multimedia and Internet technologies provide exciting opportunities for the integration of new tools in the curriculum in order to support teaching, to promote students' active engagement and enhance their ability to facilitate high order skills.

A number of ICT applications, such as computer-based laboratories, hypermedia and virtual reality applications, educational games, simulations and modeling tools, exploratory programming environments, intelligent tutors, and others are available for teachers and students (Jonassen, Howland, Moore, & Marra, 2003). Among the various ICT applications, computer simulations are of a great interest since they constitute open educational environments providing active engagement and practical experiences for learning and the understanding of concepts beyond their theoretical context.

Currently, the use of simulations covers a wide range of applications within the areas of research and analysis studies (Feinstein & Park, 2002; Hanan, Prusinkiewicz, Zalucki, & Skirvin, 2002; Mesa, Navarro, Steinmetz, & Eke, 2003; Washington, Weatherly, Meehl, Semtner, Bettge, Craig et al., 2000), system design (Axelrod, 1997; Lorek & Sonneschein, 1999), training and education (de Jong & Joolingen, 1998; Jimoyiannis & Komis, 2001; Lee, Nocoll, & Brooks, 2004; Ziv, Small, & Wolpe, 2000), entertainment (Leemkuil, de Jong, & Ootes, 2000), and physical therapy (Merians, Jack, Boian, Tremaine, Burdea, Adamovich, et al., 2002).

Computer simulations are becoming more generally recognised as efficient learning environments where students can explore, experiment, question, and hypothesise about real life situations (natural or social), which would be inaccessible otherwise. Simulations can offer substantial benefits in education by overcoming obstacles of doing experiments, through replacing real world systems, overcoming drawbacks of those systems, visualising invisible processes, and offering multiple views and multiple representations of the situated system.

In this article, the basic characteristics of scientific and educational simulations are discussed. Research findings which support their educational effectiveness are presented, and emphasis is placed on the pedagogical issues of designing and using simulation environments aiming at facilitating students' engagement and active knowledge construction.

SCIENTIFIC SIMULATIONS

Generally speaking, a simulation is a technique of imitating the behaviour of a situation, process, or system by means of an analogous system. In the simplest sense, a system is a set of interacting identities. In the case of scientific simulations, this analogous system is a *mathematical model*. The mathematical equations that produce the model represent the various processes which take place within the target system. In other words, this model constitutes a simplified or idealised representation of a system by means of a set of mathematical equations (algebraic, differential, or integral). The mathematical model becomes a simulation by solving numerically (i.e., for varying sets of input values) the equations comprising in order to imitate or simulate the dynamic (time-varying) behaviour of the system (Fishwick, 1995).

In a computer simulation, the mathematical model is produced by proper executable algorithms, which are used to solve the mathematical equations. Consequently, a computer-based simulation is a software application that embodies a model of the actual or theoretical system, executing the model on a computer and analysing the output. Any system in either the micro- or the macro-world can be simulated, providing that its behaviour can be described by a computer model (algorithm). Usually, a simulation model is an abstraction that behaves somewhat like the original system, thus allowing users to replicate only a small part of the actual system under investigation (e.g., its key features or characteristics).

The common perception of a simulation is that of an interactive computer program that replicates, within limits, some object, phenomenon, situation, or process of the real or the imaginary world. There is a confusion between simulations and other computer applications which have a similar-looking output like *animations* or *visualisations*. Simulations differ substantially because they predict an output based on a series of inputs. On the other hand, computer animations do not use any underlying model to calculate the behaviour of the system while they simply display a series of precalculated values. In conclusion, there are two key features which define a computer simulation (Thomas & Milligan, 2004):

- A *computer model* of a real or theoretical system that contains information on how the system behaves (formal entities, properties, and rules or relationships among them).
- *Experimentation* can take place; for example, the user can change the input to the model, thus affecting its output behaviour (Figure 1).

Two methods of simulation distribution are available: CD-ROM or Web-based format. A CD-ROM is suitable when the simulation material needs extensive memory and it would be too time-consuming for the user to download it from the Web. On the other hand, using a Web format makes the material immediately available from virtually anywhere in the world, independently of the computer platform used. Furthermore, material on the Web can be readily updated and easily structured through hyperlinking techniques, thus making clear the relationships between the various parts.

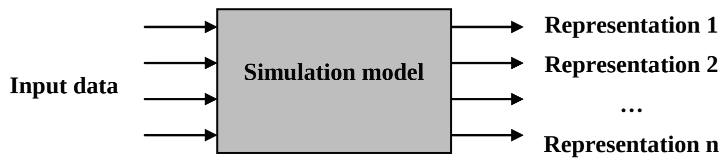
Basically, two different technologies are used to support simulations development. *Multimedia* simulations mainly use a two dimensional (2D) representation to simulate the natural world, and, as a consequence, they lack realism. Alternatively, *virtual reality (VR)* simulations constitute a realistic 3D, highly interactive, multimedia environment in which the user becomes a participant in a computer-generated virtual world. The key feature of VR simulations is real-time interactivity, where the computer is able to detect user inputs and instantaneously modify the virtual world in accordance with user interactions. VR simulation environments could be *explorative* or *immersive*. The latter consist of special hardware parts including head-mounted displays, motion-sensing data gloves, eye phones, and others.

SIMULATION DESIGN

The process of designing and building a simulation is known also as modeling process. Modeling, in general, is a way of thinking and reasoning about systems. The goal of modeling is to come up with a representation that is easy to use in describing systems in a mathematically consistent manner (Fishwick, 1995). Moreover, modeling aims at the prediction and understanding of the behaviour of the target system under a range of conditions. The creation of models is a dynamically evolving cyclic process, and, in general, four main stages can be identified within it (Fishwick, 1995; Thomas, 2003):

Conceptual model formation: This is an abstraction process whereby the designers define a simplified representation of the system. Conceptual modeling incorporates: (a) identification of the components of the systems and the boundaries or limits of the corresponding model, (b) revealing and defining rules and relationships between the various entities, and (c) creation of new information in cases where there

Figure 1. The simulation process



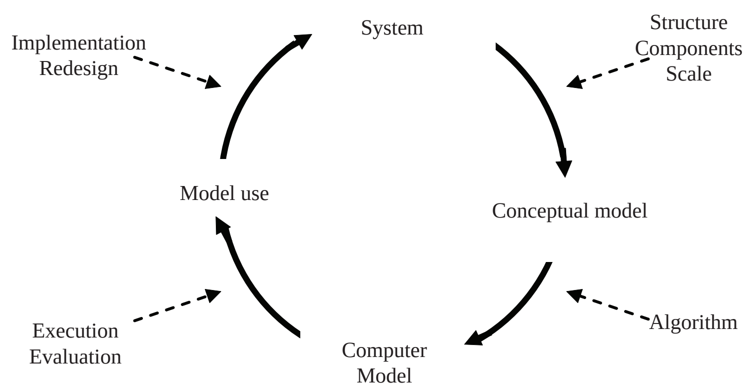
is no information available. During this stage, the components of the system and their key relationships must be established (Covert et al., 2001). Finally, the designers must decide upon the characteristics of the model, that is, its scope (application and people to use it), its type (quantitative or qualitative), its structure (discrete, continuous, or hybrid), its behaviour (discrete or continuous), and its scale. For some systems, there may be an analytic solution and a set of equations that define the model adequately; in others, the computer must be used to estimate a solution. Approximations or simplifications (e.g., ignoring rotation in the simulation of a projectile's motion) are introduced to reduce complexity, computational requirements, and solution's time.

Quantitative model specification: During this phase, the appropriate mathematical equations necessary to describe and model the system must be specified. These equations must be converted to an algorithm that can be executed on a computer. The computer model (algorithm) should accomplish three main properties (goals): (1) *validity*: it must be validated to ensure that it matches the target model and its output reflects accurately the behaviour of the real world system; (b) *usability*: to allow the researcher or whoever will use the simulation to interpret its output and understand how it works; and (c) *extendibility*, to allow designers or any future user to adapt the model for novel uses. A simulation is much more likely to be extendible if it is written and documented by taking into account this goal. Model specification is an iterative process that is repeated until a sufficiently accurate model is obtained.

There are two main ways of constructing computer models: (a) *programming languages* (e.g., C, C++, Visual Basic, Java, etc.), which can be used to construct simulation models from scratch, and (b) *simulation tools* available for different types of modeling, for example, dynamic systems (AgentSheets, Flexim, Model-It, ModelMaker, PowerSim, SimQuest, Stella) or discrete systems (Arena, Simul8). Simulation tools are usually domain-specific and therefore cannot be used to simulate systems of other domains in a reasonable way. Special simulation or modeling languages, like 20-sim, Dymola, Modelica, and so forth, are superior to ordinary programming languages since they provide particular functionalities (time control, set manipulation, data visualisation, statistics gathering and reporting, and so forth) and rich model libraries. Supportive utilities, such as multimedia authoring tools or VR tools, are also used.

Model execution and evaluation: In this stage, the simulation is executed on a computer and its performance is compared with that of the real world system. The simulation should be able to produce the same sorts of data and input/output relationships that were initially gathered. Once the computer model is constructed, the designers conduct experiments to solve problems in order to obtain a better understanding of the system. The model is regarded as being valid as long as the simulation can accurately reproduce the real world data. A variety of factors can make a simulation invalid quite apart from the fact that the underlying equations might be inaccurate (for example, errors in input data and programming, constraints of

Figure 2. The modeling cycle



the programming language, etc.). Techniques such as *sensitivity analysis* and *validation of accuracy* are used at this stage (Thomas, 2003).

Model use: Once the simulation has finally been completed, it may be used as an empirical research tool aiming at the understanding of the system. Thorough research will inevitably reveal flows, deficiencies, or inadequacies of the model and will therefore lead to model revision or redesign. This process may ultimately conclude to the development of an entirely new model. A new modeling cycle may begin again (Figure 2), as the original system could be changed by proper interventions or refinements.

USING SCIENTIFIC SIMULATIONS

Fundamentally, the role of scientific simulations is to act as a virtual laboratory. During the last decades, they have dynamically evolved as a new form of scientific tool. Regarding their applications, simulations tend to play one of the following subsidiary roles within the framework of scientific research:

Complementary to empirical investigation: This can be done through experimenting or observing the natural world. There are numerous complementary benefits offered by simulations, especially in the cases of complex systems described by many interrelated variables, when the relationships between variables are nonlinear or when the underlying model contains random variables, and so forth. Once a simulation has been validated against real-world or experimental data, it can be used to pose specific questions to predict the outcomes of real experiments and provide a quantitative basis of system study in order to help researchers in achieving qualitative understanding (Covert et al., 2001; Hanan et al., 2002; Washington et al., 2000; Wiechert, 2002).

Superior to empirical investigation: There are numerous reasons as to why simulations are considered by many researchers as superior to the experimental or direct observation of a system under study (Meza et al., 2003; Washington et al., 2000); namely, simulations (a) allow more control, (b) allow more detailed investigation, (c) offer time compression or expansion, and (d) constitute a less dangerous and costly investigation tool.

The only method for empirical investigation: There are various reasons that do not allow an experiment or an observation to take place in order to investigate a system (Axelrod, 1997; Feinstein & Parks, 2002). For example, simulations offer the only possibilities for experimentation on ecosystems (Grant & Thompson, 1997; Lorek & Sonnenschein, 1999). There are also ethical or safety concerns, for example, medical training (Gibson, Fyock, Grimson, Kanade, Kikinis, Lauer, et al., 1998), car crash accident (Simpson, Johnston, & Richardson, 2003), or a nuclear war study. Finally, in many cases, there are needs for time expansion or compression (a fast-fire starting or the development of a new forest), spatial scale problems, or extreme conditions not easily reached in laboratory settings, for example, galaxy formation (Meza et al., 2003), climate models (Washington et al., 2000), and so forth.

EDUCATIONAL SIMULATIONS

Scientists create simulations on various domains, such as technology, physics, chemistry, biology, medicine, environmental sciences, social and financial studies, and so forth to facilitate their research, to express and test their theories, and to improve their understanding about complex systems. Scientific simulations are, usually, too complex to be used in the various educational contexts. Educational simulations are created in order to facilitate students' or trainees' learning. Because of its purpose, an educational simulation is an abstracted representation of the target system, which is neither as complex nor as realistic as the corresponding scientific one. De Jong and Joolingen (1998) have divided educational simulations in two main categories:

a. **Operational simulations:** Operational simulations are designed to facilitate the construction of practical knowledge, for example, in areas such as medical training, pilot training, and so forth (Gibson et al., 1998; Leemkuil et al., 2000). They are based on *operational models*, which allow students to both practically and psychologically play the role for which they were trained (e.g., the role of a surgeon or a pilot). Operational simulations often use nonstandard input and output mechanisms.

b. **Conceptual simulations:** On the other hand, conceptual simulations are designed to facilitate conceptual knowledge construction on the part of the students. They are based on *conceptual models* (used within subject domain education), which simulate the relationships that exist between the variables of a real-world system, while at the same time allowing the user (student) to manipulate those variables.

There are four main building blocks in an educational simulation (Alessi, 1988): the *underlying model*, the various *presentations*, the *user actions*, and the *system feedback* (human-computer interaction). According to Maier and Grobler (2000), computer simulations have three key aspects: the underlying *mathematical model*, the *human–computer interface*, and the various *functionalities*. They consider underlying model as being a major part of a computer simulation, and they place the rest of Alessi's components under a new category which comprises the characteristics of a human–computer interface. They have also added a new component, named *functionality* in order to cover those characteristics of computer simulations that are not determined by the underlying model or the human–computer interface. For example, functionality involves access to additional source materials, the extent to which the structure of the underlying model is explicitly shown (degrees of transparency), the progress of time within the simulation (time-step), and so forth.

Conceptual simulations are considered to be effective educational environments aiming at enhancing teachers' instructional potentialities and provoking students' active engagement. They have been proposed as effective tools for supporting students' understanding since they behave in a similar way to the system or the process modeled. They offer a great variety of opportunities for modeling concepts and processes and therefore provide a bridge between students' prior knowledge and the learning of new physical concepts, and help students develop scientific understanding through an active reformulation of their misconceptions (Jonassen et al., 2003; de Jong & Joolingen, 1998; Jimoyiannis & Komis, 2001).

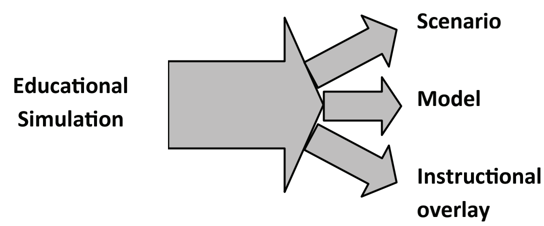
Designing Efficient Educational Simulations

In the attempt to describe the building blocks of an educational simulation, within the framework described by Alessi (1988), three main components can be identified (Figure 3): the *simulation scenario*, the *mathematical model* of the target system, and the *instructional overlay*. The components above collectively define the body of knowledge to be learned and how learning is approached or supported by the simulation environment.

Scenario-related issues concern model focus and the degree of model modification and model transparency incorporated (for teachers and students also). In many cases, teachers prefer to modify a modeling scenario in order to provide a different task to their students, stimulate their involvement, make them be more focused on a particular aspect of the model, describe different phenomena, and so forth. It is preferable that students at different educational levels, and students who have different skills, interests, or educational needs, could use the same model. For example, the teacher may wish a model that could be simplified for novice users, allowing them to access a limited number of model variables or to vary the degree to which students are allowed to view or manipulate the underlying mathematical model. Various simulation tools, like Interactive Physics, Modellus, Tina, ChemLab, Modelling Space, SimForest, Explore-It, among others, offer those possibilities as well.

The mathematical models, upon which *operational simulations* are based need to be as realistic as possible since they are being used for training in specific real-world procedures such as medical procedures (Gibson et al., 1998). On the other hand, the mathematical models upon which *conceptual simulations* are based are usually simplified to some degree in order to facilitate learning. Such a simplification is necessary because increasing

Figure 3. The basic components of an educational simulation



complexity increases the time required by students to understand the simulation and so does the likelihood that they will become frustrated and demotivated (Bos, 2001). By reducing simulation realism, therefore, the conceptual simulation designer can clarify complex or difficult concepts and can tailor the simulation to the students' prior knowledge and experience.

The third component of a conceptual simulation, the *instructional overlay*, is made up of those features defining the educational context and the representational forms used, the educational approach (discovery or expository learning) and tasks used, and, finally, learner motivation, guidance, assistance, and feedback (Hmelo & Day, 1999; Lee et al., 2004; Leemkuil et al., 2000). A well-designed instructional overlay can: (a) prompt and motivate students, (b) incorporate questions that will direct students towards educational goals, (c) focus students' attention upon educationally important aspects of the simulation, and (d) progressively unfold the complexity of a simulation over a series of stages in order that students not be overwhelmed by it.

Creating a model of a single object or event is usually an easy task. However, a simulation model of an entire virtual world, in which all objects and events are represented in a consistent and complimentary manner, requires a great deal of mental and creative effort. Moreover, developing computer-based simulations for learning is not only a technical matter; however, such systems should combine both modeling and instructional knowledge with a pedagogical strategy (Joolingen & de Jong, 2003).

The following interrelated parameters (phases) could define a consistent framework for building efficient education simulations:

Instructional design: First of all, one has to estimate the learners' attributes and their prior subject knowledge and also define the learning goals associated to the body of domain knowledge to be learned. The following is the design of students' activities that will be performed, and the estimation of the didactical knowledge or any other relevant information from the didactics of the subject matter.

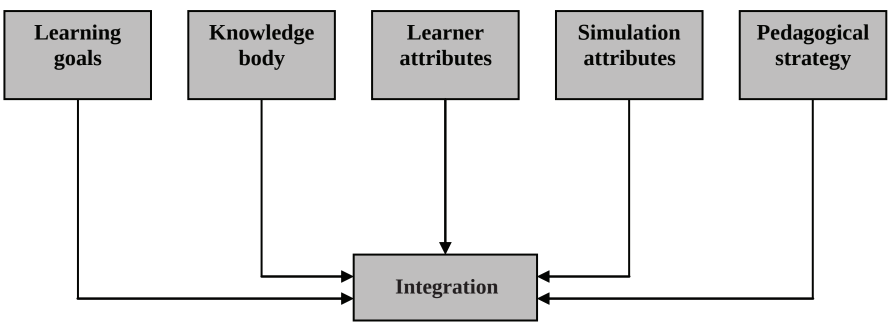
Learner interface: During this phase, we create the simulation interface and embody the tools appropriate to visualise and represent knowledge effectively for the learners (graphs, tables, vector, or textual representations). An educational simulation must offer different views of the underlying model from textual to graphical representations. As Ainsworth (1999) has shown, different representations used simultaneously can constrain interpretation, construct deeper understanding, or complement each other.

Pedagogical strategies: In general, pedagogical strategies define how learning is approached within the system (e.g., exploratory or discovery learning; this determines the models to be discovered or experienced by the learners). Another issue is the instructional interventions to be incorporated (e.g., explanations, exercises, tasks, or other type interventions).

Simulation model creation: This phase incorporates identification and definition of the underlying simulation model (parameters, relationships among them, limits, representations used, models' type, structure and behaviour, user interface interactions, student supporting tools, etc.)

Integration: All the information and the outcomes above should be integrated to a complete system capable to support students' meaningful learning and teachers' role as efficient facilitators (Figure 4).

Figure 4. Educational simulation aspects



CONSTRUCTIVIST LEARNING BY USING SIMULATIONS

Over the last decades, the constructivist view of learning is dominant among scholars and researchers (Driver, 1989; Duit & Treagust, 2003; Von Glasersfeld, 1987). According to this view, students do not passively absorb information but meaningful learning, rather, occurs through an active process of creation and modification of knowledge structures. Students achieve learning through using their existing knowledge, beliefs, interests, and goals in order to interpret any new information. This may result in modifying or revising their ideas. In this way, learning occurs as each individual's conceptual schemes are progressively reconstructed while the person becomes exposed to new experiences and ideas.

There are two main constructivist schools: (a) *Cognitive constructivism* which places emphasis on the personal construction of knowledge. According to this view, teachers have a relatively peripheral role in providing suitable experiences that will facilitate learning; and (b) on the other hand, according to *social constructivism*, knowledge is socially constructed and learning takes place in particular social and cultural contexts (Vygotsky, 1978). In both cases, the emphasis is on interactive-rich educational environments where students are given opportunities to interact with adults, peers, and knowledge in order to negotiate their meaning. According to this view, teachers have a central role in providing guidance and support to learners (scaffolding). Through this process a teacher can gradually guide students to develop their knowledge and skills while making connections with their pre-existing mental models and schemes.

Within a constructivist framework of learning, simulations may offer strong benefits not only by facilitating constructivist-learning activities but also by supporting different types of learners. Many researchers have advocated the educational potential of computer-based simulations, based on the fact that the latter provide opportunities for *active learning* (de Jong & Joolingen, 1998; Jonassen et al., 2003), enable students to perform at *higher cognitive levels* (Huppert, Yaakobi, & Lazarowitz, 1998), and promote *conceptual change* (Jimoyiannis & Komis, 2001; Tao & Gunstone, 1999). For instance, students may vary a selection of input parameters and observe the extent to which each individual parameter affects the whole system. Alternatively, they can explore combinations of parameters and observe their effect on the evolvement of the system. Educational computer simulations constitute open learning environments that provide students with opportunities to (Jimoyiannis & Komis, 2001):

- Access, visualise, and investigate dynamic phenomena and situations which are otherwise difficult to experience in a classroom or lab setting because they are extremely complex, technically difficult, dangerous, unethical, money- or time-consuming, happen too fast or very slowly, and so forth.
- Introduce simplified concepts prior to developing complexity
- Support a qualitative understanding of complex systems knowledge
- Develop a conceptual understanding about phenomena and laws through an active process of hypothesis-making and ideas testing by changing the input variables and observing the effect directly on the output
- Isolate and manipulate parameters in order to develop meaningful understanding of the relationships between concepts, variables, and phenomena
- Employ a variety of representations (pictures, animation, graphs, vectors, and numerical data displays) which are efficient in understanding the underlying concepts, relations, and processes
- Express their own representations and mental models about real world phenomena, situations, or systems

The constructivist perspective of learning argues that knowledge is not transferred to students' minds but it is rather achieved by constructing efficient models of the natural world. Hestenes (1992) has distinguished two types of models: (a) *mental models*, which are representations of the physical phenomena constructed by students containing a set of information about what they know (either correct or incorrect) and (b) *conceptual models*, which originate from mental models and are created by the cooperative activities of scientists and domain specialists. These are objective representations in the sense that they are independent of any particular individual. There is also a third type of model, constructed by domain and education specialists that one could name *didactical models* since they aim at helping students achieve conceptual understanding. Students' active engagement with didactical models is essential to overcome conceptual obstacles and construct scientifically valid conceptual models. Bliss (1996) has also analysed the differences between two types of models in educational simulations.

a. **Exploratory models:** They are constructed by experts to represent domain knowledge and/or simulate complex processes and laws. These environments encourage students to explore and interact with them, to handle various input parameters and, finally, to observe their results.
b. **Expressive models:** They allow students to express their own ideas on a domain. They provide learners with tools to define relationships between concepts, explore the consequences of those student-defined relationships, and learn through an active process of representing their own models.

In this framework, we have suggested that educational simulations can be used in three different ways (Jimoyiannis & Komis, 2001):

- As an **artifact**, which helps teachers to demonstrate explicit visual representations of complex systems and relations in order to support their lecture or explanations
- As a **virtual laboratory** representing an exploratory world where students can use models to conduct experimentation, to create and test hypotheses and, finally, construct their own understanding
- As a **student activity**, which aims at students' constructing and presenting their own (expressive) models through a meaningful learning experience.

Computer simulations have been successfully applied from primary and secondary schools (Davies, 2002; Huppert et al., 1998; Jimoyiannis, Mikropoulos, & Ravanis, 2000; Pallant & Tinker, 2004; Tao, 1997) to university education (Granlund, Berglund, & Eriksson, 2000; Hundhausen, Douglas, & Stasko, 2002; Schroeder & Moore, 1993; Warner, Catterall, Gregor, & Lipson, 2000) covering various disciplines. There are many studies providing us with supportive evidence regarding the effect of computer simulations to activate students to motivate them in order to perform at higher cognitive levels (creative and analytic thinking, skills development, problem solving skills and abilities) and to promote conceptual change and knowledge construction.

Figure 5. Simulation of a satellite moving around the earth through interactive physics

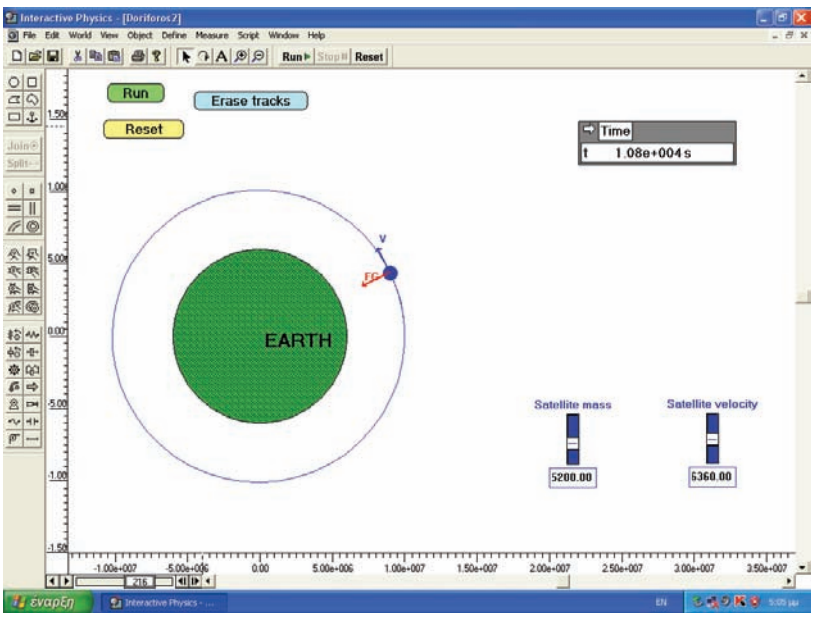
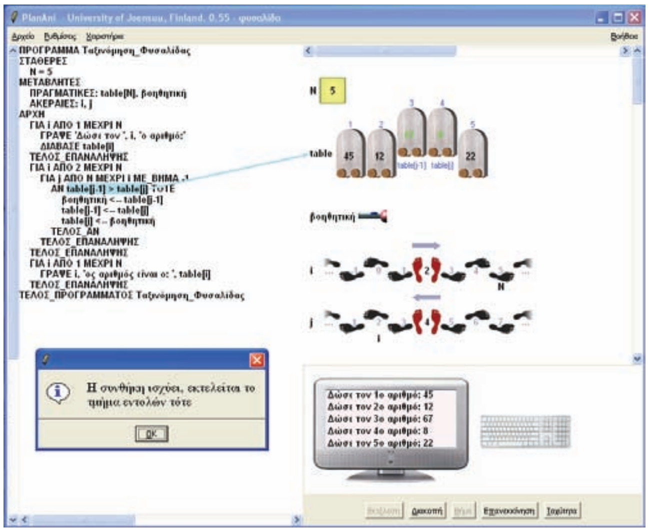


Figure 6. Simulation of the bubble-sort algorithm through PlanAni(GR)



Bakas and Mikropoulos (2003) have studied the effect of a VR simulation environment on students' comprehension of planetary phenomena. In their study, Peña and Alessi (1999) have showed that simulations were equally effective to microcomputer based labs in facilitating comprehension of the concepts involved in objects' free fall. The combination of simulations and the Web can create powerful and dynamic learning environments (Lee et al., 2004). Efficient Java applets may be found on many educational sites and are frequently used as supplements to classroom lectures and traditional labs (e.g., JeLSIM, Physlets, Easy Java Simulations, etc.).

Figure 5 shows a screenshot of Interactive Physics presenting the simulation of a satellite moving around the earth. This simulation is a model paradigm that can be used according to the ways shown above, for example, as a visual representation to support teacher's instruction, as a virtual laboratory for students to explore and study this phenomenon, and as a student activity to build it from scratch. This last activity gives the students the opportunity to think scientifically about the behavior of complex systems, to reflect upon their own understanding, to test and refine their own mental models, and, finally, to construct valid conceptual models. Simulations of this type have been used to support secondary school students' learning in the domain of kinematics (Jimoyiannis & Komis, 2001). Students in the experimental group have been engaged in tasks which demand the exploration of simulations through Interactive Physics. Results exhibited that students significantly improved their achievement rates in tasks regarding the concepts of velocity and acceleration.

Computer simulations can effectively support students and novice programmers to achieve meaningful understanding of the basic algorithmic concepts and develop their programming skills (Hundhausen et al., 2002; Jimoyiannis, Tsiotakis, & Sajaniemi, 2006; Sajaniemi & Kuittinen, 2005). PlanAni is an algorithm visualisation environment based on the idea of teaching students the *roles of variables* rather than the programs as a single unit (Sajaniemi, 2002). This notion is based on the fact that variables are not used in a random or *ad-hoc* way but there are several standard use patterns that occur over and over again in the various algorithms.

PlanAni(GR) is a new version of this simulation environment adapted to the Greek secondary school needs (Jimoyiannis et al., 2006). In Greek upper secondary schools, an ideal programming language named GLOSSA is used to support introductory programming lessons and students in developing their own algorithms. Figure 6 shows a screenshot of the PlanAni(GR) interface animating the execution of the bubble-sort algorithm. The software provides students with opportunities to:

- Visualise and simulate the overall execution of the program and the dynamic change of the values of the variables involved
- Input data and observe on the screen the way in which the execution output is produced
- Achieve different representations of the variables according to their roles in the program
- Isolate and visualise statements or complex structures, such as conditional structures or iterations (loops)
- Receive explanatory messages of the effect and the role that each variable or statement has in the program
- Use the tools embodied (start, stop, simulation speed, stepwise execution of the program) in order to achieve meaningful understanding.

Despite all these advantages and possibilities that simulations offer, teachers seem not to use them extensively in their instruction (Jimoyiannis & Komis, 2006b) while they encounter many difficulties to support simulation-based discovery learning and scaffold students' activities. De Jong and Joolingen (1998) have provided an extensive overview of the main problems and indicated how simulations could be extended to overcome these problems. Their reasoning is anchored on the basis of integrating discovery learning with instructional support. I further argue that, despite their potential, simulation-based learning environments cannot guarantee effective learning without sufficient support, both for students and teachers.

However, constructing a dynamic model is a complex task, and it is reasonable that students, as novice modelers, encounter many difficulties in accomplishing this. Sins, Savelsbergh, and van Joolingen (2005) have studied students who work in dyads, on a modeling task in the domain of physics. Their results indicate that the successful students differed from the less successful ones in using more prior knowledge and in showing more inductive reasoning. They have pointed out the importance of students' support and suggested that efficient scaffolding should: (a) encourage students to activate their prior knowledge before and during their modeling activities and (b) motivate deep reasoning about their models by testing them against multiple datasets. Students should be asked to model phenomena of which they already have knowledge or experience.

Zhang, Chen, Sun, and Reid (2004) proposed a triple learning support scheme for scientific discovery learning based on computer simulations which involves: (a) *interpretative support* that helps learners with knowledge access and activation, the generation of appropriate hypotheses, and the construction of meaningful and coherent understanding; (b) *experimental support* that scaffolds learners in the systematic and logical design of scientific experiments, the prediction and observation of outcomes, and the drawing of reasonable conclusions: (c) *reflective support* that increases self-awareness of the discovery processes and prompts their reflective abstraction and knowledge integration.

CONCLUSION

In this article, simulations' exploration and modeling have been considered a scientific activity, which can help students make their mental models explicit, develop creative and flexible thinking, and achieve meaningful learning. This is not an ideal activity while students and teachers encounter many difficulties. There is still a lot to learn about simulation-based learning, for example:

- What type of conceptual or other difficulties do students encounter? In what ways should students' scaffolding be addressed?
- What prevents teachers from using simulation and modeling activities in their classes?
- What type of support do teachers need? Is only their technological support needed or are there important pedagogical issues that must be equivalently analysed?
- What types of interventions are needed in the curriculum?

Many researchers assert that ICT integration in the educational practice is a complex and multifaceted issue and teachers constitute a critical factor (Jimoyiannis & Komis, 2006a; Kumar & Kumar, 2003; Russell, Bebell, O'Dwyer, & O'Connor, 2003). Teachers must be able, not only to use ICT tools, but also to principally reorganize their instruction by using student-centered activities, based on appropriate ICT applications. Their preparation and support programs must clearly articulate specific types of effective instructional models and representative paradigms of ICT use for every subject matter in the curriculum. It has been shown that the functionality of computers in the class has been quite different for teachers of different attributes such as gender, age, subject specialty, computer use, and teaching experience (Jimoyiannis & Komis, 2006a, 2006b).

Professional and preservice development programs should focus on changing teachers' pedagogical cultures and philosophies about the teaching and learning processes through training them on how to use appropriate ICT tools with their students. This must be organized in a framework of broader instructional reforms aiming at the *curriculum*, the *educational media*, and, principally, at the *pedagogical practices* used.

I therefore argue that it is important to consider the use of simulation-based learning environments carefully and that there is a sound justification for the pedagogical strategies used. Clearly, there is no single technology or instructional approach that can resolve all problems and meet all pedagogical needs. To increase the likelihood that simulations will be used in the school practice effectively, teachers need to be encouraged to try and acquire positive experiences about their effectiveness on teaching and learning.

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KEY TERMS

Computer Simulation: In a computer simulation, proper executable algorithms produce the underlying mathematical model. There are two key features defining a computer simulation: (a) a computer model of the target system that contains information on how the system behaves (formal entities, properties, rules, and relationships among them), and (b) experimentation can take place; for example, the user can change the input to the model, thus affecting its output behavior.

Conceptual Models: They are mental models created by the cooperative activities of scientists and domain specialists. These are objective representations in the sense that they are consistent with the relevant scientific paradigms.

Conceptual Simulations: Conceptual simulations are educational simulations designed to facilitate conceptual knowledge construction on the part of the students. They are based on conceptual models which: (a) simulate the relationships that exist between the variables of a real-world system and (b) allow the students to manipulate those variables. There are three main components in a conceptual simulation: the simulation scenario, the mathematical model of the target system, and the instructional overlay.

Constructivism: According to the constructivist view of learning, students do not passively absorb information, but rather, meaningful learning occurs through an active construction and modification of their knowledge structures. When students are learning they use their existing knowledge, beliefs, interests, and goals to interpret any new information, and this may result in their ideas becoming modified or revised. There are two main constructivist schools: (a) cognitive constructivism, which emphasizes on the personal construction of knowledge; (b) social constructivism, which emphasizes on knowledge construction in particular social and cultural contexts. In both cases, the emphasis is on interactive environments where students are given opportunities to negotiate their ideas and meanings. According to this view, teachers have a central role in providing guidance and support to their students (scaffolding).

Educational Simulation: It is a computer simulation created to facilitate learning on the part of students or trainees. Educational simulations are abstracted or simplified representations of a target system, which are neither as complex nor as realistic as the relevant scientific simulations.

Instructional Overlay: It is the component of a conceptual simulation, characterized by those features defining the educational context, the representational forms, the educational approach, and the tasks used. A well-designed instructional overlay should: (a) prompt and motivate students' engagement, (b) incorporate feedback and other tools that may assist and guide students towards the educational goals, (c) focus students' attention upon cognitively important aspects of the simulation, and (d) unfold the complexity of the simulation over a series of stages in order that students not be overloaded or overwhelmed.

Mental Models: They are schemata and representations of the real world phenomena constructed by students. They contain a set of information about what students already know, either correct or incorrect. Students usually exhibit mental models, which are not consistent with the relevant scientific paradigms.

Operational Simulations: They are educational simulations designed to facilitate the construction of practical knowledge, for example, in areas such as medical training, pilot training, and so forth. They are based on operational models, which use nonstandard input and output mechanisms.

Scientific Simulation: It is a technique of imitating the behavior of an actual or theoretical system by means of an analogous mathematical model. In the simplest sense, a system is a set of interacting identities. The mathematical equations that produce the model represent the various processes taking place within the target system. Currently, simulation uses cover a wide range of applications within the areas of research, analysis studies, system design, training and education, entertainment, and so forth.

Virtual Reality (VR): It is a three-dimensional (3D), realistic and highly interactive multimedia environment, in which the user becomes a participant in a computer-generated virtual world. The key feature of a VR simulation is its real-time interactivity, where the computer is able to detect user inputs and instantaneously modify the virtual world in accordance to user interactions. VR-based simulation environments could be explorative or immersive (which consist of special hardware parts including head-mounted displays, motion-sensing data gloves, eye phones, etc.).

APPENDIX

Table 1. Simulation tools and environments mentioned in the text

Simulation-modeling environment	URL
20-sim	http://www.20sim.com
AgentSheets	http://www.agentsheets.com
Arena	http://www.arenasimulation.com
ChemLab	http://modelscience.com
Dymola	http://www.dynasim.se
Easy Java Simulations	http://fem.um.es/Ejs/Ejs_en/index.html
eM_Plant	http://www.emplant.de/simulation.html
Explore-It	http://exploreit.com/aboutUs/overview.htm
Flexsim	http://flexsim.com
Interactive Physics	http://www.krev.com
JeLSIM	http://www.jelsim.org/
Modelica	http://www.modelica.org
Model-It	http://hi-ce.org/modelit
ModellingSpace	http://www.modellingspace.net
Modellus	http://phoenix.sce.fct.unl.pt/modellus
ModelMaker	http://www.modelmakertools.com/
Physlets	http://webphysics.davidson.edu/Applets/Applets.html
PowerSim	http://www.powersim.com
SimForest	http://ddc.hampshire.edu/simforest/software/software.html
SimQuest	http://www.simquest.com
Simul8	http://www.simul8.com/
Simulink	http://www.mathworks.com/products/simulink
Stella	http://www.iseesystems.com/softwares/Education/StellaSoftware.aspx
TINA	http://www.tina.com
Vensim	http://www.vensim.com/software.html

Computer-Mediated Communication Learning Environments: The Social Dimension

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INTRODUCTION

The social, relational, and affective dynamics are receiving more and more attention in the study of learning processes, as cognitive, affective, and emotional dimensions of learning seem to be closely related. This kind of co-origination, borne out in the context of neurosciences, artificial intelligence, cognitive psychology, and education, has also been recognized in the field of Web-based learning. The research framework of computer supported collaborative learning (CSCL) has emphasized the role that a well-established social dimension plays in collaborative learning and group-based working within communities of learners. According to the socioconstructivist model, learning always implies a social dialogical process where individuals are mutually engaged in the construction and sharing of new knowledge (Scardamalia & Bereiter, 1994; Wenger, 1998). Pedagogical approaches based on these assumptions combine the advantages of a learning strategy that promotes deeper level learning, critical thinking, and shared understanding with those related to the development of social and communication skills (Garrison & Anderson, 2003).

What characterizes the intertwining of the educational and sociopsychological dimensions in these settings is that they are strictly linked to the dialogues that participants mutually construct. Most of the learning experiences that occur on the Internet are characterized by written and asynchronous communication (Lapadat, 2002). And the written discourse deeply influences also the socio-affective dimension of learning.

The present review aims at presenting the most recent and promising research studies that tackle the linguistic nature of the emotional and affective dimension of learning in Web-based learning environments. Its purpose is to emphasize how computer-mediated communication (CMC) may convey specific social affordances in the expression of affective and social domain of learning.

BACKGROUND

Early approaches in the study of CMC noted that the lack of nonverbal cues (e.g., facial expression, posture, gesture, proximity) would limit the richness and scope of communication (Short, Williams, & Christie, 1976). CMC was thought to be an impoverished means of communication giving little chance to gather important information about the context, the commonly shared rules of conduct and their influence on communication, all of which foster uninhibited speech and flaming. Moreover, as anonymity, which is a frequent feature of online interactions, reduces these control indicators, communication would be more de-individualized and de-personalized, and that would have different and unpredictable consequences on the various speech contexts. Lacking nonverbal indicators, CMC was seen to be characterized by a very low level of social presence, and it was thought that this feature could invalidate the learning purpose.

In recent times, a number of studies have shown that with written communication alone, typically used in chat and e-mail, it is possible to stimulate social and affective presence, provided that interlocutors are allowed to manage their time freely. Other authors underlined the similarity between the development of relationships in both face-to-face and online contexts, showing that although the latter need more time to grow, they can be more socially oriented than the former (Walther, 1996). Users compensate for the communicative lack of written discourse with linguistic inventions and adaptations (e.g., emoticons, typographical marks, and other textual features, including the use of capital letters, ellipses, exclamation marks, as well as typing errors) in order to express with appropriate orthographical strategies the aspects of nonverbal communication (Crystal, 2001). In this way, a higher degree of familiarity and intimacy in content, style, structures, and timing of the exchanged postings would not only be a linguistic adaptation able to incorporate colloquial and informal registers, but it could also strike a balance between the features of the medium and an acceptable level of immediacy.

In the context of distance learning, social presence has been recently redefined as "the ability of participants in a community of inquiry to project themselves socially and emotionally, as 'real' people (i.e., their full personality), through the medium of communication being used" (Garrison, Anderson, & Archer, 1999, p. 94). According to this reformulation, social presence seems to support cognitive objectives as it encourages and supports meaningful critical thinking processes in a community of learners. Emotion arousal influences the cognitive, metacognitive, and motivational aspects of the learning process, especially when socially oriented (Wosnitza & Volet, 2005) and affective objectives that result in engaging and rewarding group interactions may lead to an increase in academic, social, and institutional integration and results (Rourke, Anderson, Garrison, & Archer, 1999).

The studies that have adopted this new conceptual perspective have investigated social presence, among other characteristics, as a predictor of satisfaction and perceived learning (Richardson & Swan, 2003) and as an indicator of success and quality of the learning experience (Swan & Shih, 2005). Others underline the relationship between the role of the tutor/instructor and the affective and cognitive learning in the online classroom (Baker, 2004). All of them focus on the fundamental connection between the cognitive and affective elements of learning processes.

THE LINGUISTIC EXPRESSION OF THE SOCIAL DIMENSION OF LEARNING

If traditional approaches to measuring social presence and the affective dimension of learning used different combinations of survey instruments (e.g., scale-graduated questionnaires and semistructured or unstructured interviews) and analyses of students' online interactions through quantitative methods (e.g., frequency of messages, etc.), in recent times, the expression of the social dimension has been investigated through other means. Since the pioneering work of Henri (1992), the content analysis approach has become one of the most valuable ones. Classifications of text features into categories and indicators have been proposed, with the aim of capturing the new styles and characteristics of human communication which rely on asynchronous written discourse.

There are a number of ways in which textual indicators are able to manifest social presence and express representation of learners' affective domain. Rourke et al. (1999), for instance, identified 12 indicators of social presence belonging to three categories (affective, interactive, and cohesive), based on previous research, literature, and analysis of transcripts, which were applied to transcripts of online communication. To these, Swan and Shih (2005) added new indicators that match quite well with the ones derived both from face-to-face analysis and research on previous online learning.

Job-Sluder and Barab (2004) examined how participants in a community of practice express a shared group identity in their discussions on the basis of the use and frequency of singular and plural first person pronouns; the aim of the study was to investigate the role of identity formation in learning processes in the context of preservice and in-service teacher development. Inductive methodology guided the approach of a research study that proposes a model of engagement able to capture the dynamic nature of learners' interaction by means of the philosophical hermeneutic circle (Ziegler, Paulus, & Woodside, 2006). These studies have contributed to emphasize the importance that linguistic specificities of written communication have in the expression of social presence and affective dimension of learning. Linguistic creativity is indeed what distinguishes writing in CMC settings from written language in other kinds of communicative contexts (Crystal, 2001). Yet, the examination of specific features of language in creating an effective climate of social presence has not been carried out adequately.

Only in recent times, for instance, the role that metaphors and figurative language in facilitating the expression of emotions and affective domain in Web-based learning environments has been investigated. Literature in linguistics and cognitive science state that metaphoric language has a central role in every day discourse, because it seems to shape the ways in which we think, creating a bridge from abstract domains to perceptual experience and helping to understand a new domain of experience in terms of what is already familiar. Moreover, figurative language has a central role in establishing a climate of closer intimacy between speakers, as the power of imagery seems to facilitate the sharing of personal experience and to create emotional involvement. Studies in Web-based learning settings have shown that figurative language may be a creative way through which students at a distance may give substance and concreteness to the immaterial place of the Web. It can allow participants to represent their affective domain (their emotions and feelings) and to conceptualize the main learning components on the Web (Manca & Delfino, 2007). In this study, the use of figurative language, as a special communicative tool that creates that sense of closeness and intimacy that literal language cannot achieve, is shown to be an original and creative way to communicate through the written expression of emotions and social presence.

NEW HORIZONS OF EXPLORATION

In an online learning community, cognitive and meta-cognitive processes are closely linked with the social and affective dimensions. Learning always involves a deepening process of participation in a community, and it is closely connected to that of construction of identity. Being part of a group or a community means, most of all, building a common and shared identity with the other members. Indeed, participation especially implies the reorganization of individual identities and the construction of a collective and shared identity within the community (Wenger, 1998).

If we assume that participants are able to construct individual and collective identities, as well as to express their emotional and affective horizons through writing processes, we need to ask how one projects oneself on the Web and which images of self are constructed and proposed to others. In the context of learning settings, cyberspace may be a “space” where the narratives of the self usually maintained in a face-to-face situation are more readily disrupted. Hence, there is more possibility of exploring modes of identity formation, both on the students’ and tutors’ side (Bayne, 2005).

From this perspective, narrative is being recognized as one of the most promising and emerging areas of interest in digital learning environments (Dettori, Giannetti, Paiva, & Vaz, 2006). Narrative has been shown to be a powerful cognitive tool for meaning construction in organizing external knowledge representation and as a way to structure human experience. Storytelling, as a means through which people may communicate their emotions and feelings, is strictly intertwined with those aspects of learning related to motivation, engagement, social interaction, and personal meaningfulness. In CMC learning contexts, the use of narratives can improve the social dimension of online learners and contribute to collaborative student learning through the sharing of personal experiences and the construction of a common identity.

Another promising approach is based on the theory of dialogical self. The relatively new concept of dialogical self in psychology is closely related to narrative psychology, constructivism, and cultural psychology. It explores the reciprocal influences that occur between the construction of the self and the cultural environment, as well as the specific impact of digital environments. In an online learning environment, self-positioning strategically supports the creation of a virtual learning community and also stresses the relationship of individual development with the sense of belonging to a community (Ligorio & Pugliese, 2004).

From a methodological perspective, along with approaches that tackle the content analysis of written communication, other methods are gaining further consideration. Among others, social network analysis focuses more on the study of the whole learning community, rather than on the individual who takes part in it. It examines the ways in which participants communicate with each other by exploring the depth of collaboration and the frequency of communication between participants, considering notions such as relation and structure of a network. The first applications of these notions to online communities have revealed that this method is especially helpful for understanding how a community is born and grows through the complexity and density of the network nodes and links (e.g., Aviv, Zippy, Ravid, & Geva, 2003).

CONCLUSION AND IMPLICATIONS FOR PRACTICE

The constant growth of online education is rapidly changing how and when people, especially adults, choose to engage in a learning experience. Today, it is more a question of choosing the most convenient and personally suitable way to receive “instruction” and training rather than attending a traditional “physical” institution. This shift of perspective is gradually changing our view of the social nature of learning processes, too. The latter, as we have seen, are always deeply intertwined with the affective, emotional, and relational factors that usually emerge in a community of learners. In contexts of such a nature, the process of learning is mostly interrelated with that of becoming, the process of sharing practices and knowledge with that of constructing a common and shared identity.

Identifying new and more suitable methods with which to investigate how these relationships are constructed is becoming an imperative in the field of ICT. More conservative views of the ways people experience the immaterial dimension of learning in cyberspace should be accompanied by, if not substituted with, new and more appropriate methods. This sort of paradigm shift also affects how affectivity and sociability, which influence and transform the learning dimension, should be investigated. Becoming aware of the potentialities of learning communities that rely on written discourse communication would enhance our exploration of these processes and help us to design and support more effective learning environments based on ICT use.

Previous sections have enlightened how written communication is able to convey specific and unique social and emotional affordances in the context of Web-based learning. For this reason, rather than comparing face-to-face and online settings and seeing the latter as characterized by an impoverished communication, researchers should look at how the pragmatic needs of an online setting might be satisfied thanks to the richness of written language. These considerations have profound implications for practitioners as well. The examples shown above underline that numerous are the textual indicators of social presence in Web-based learning environments that could be adopted in the design and conducting phases. The use of figurative language (in the forms of metaphors, analogies, etc.), for instance, may be encouraged and adopted during the design and conduct of online learning courses as a stimulus to manifest and share those personal emotions and feelings that are always deeply rooted in any new learning experience. The adoption of metaphors by tutors may foster students' sense of belonging to a larger community and provide a framework for role assignment, identity, and responsibility. Along with other facilitation measures, tutors/instructors would be able to use a further feature of aiming at encouraging interaction based on figurative language that would serve as a stimulus to facilitate the intertwining of the social dimension with learning processes.

On the narrative side, measures of this kind may be adopted as a more effective means of achieving quality discussions more than using traditional materials. Online instructors could combine encouragement of personal storytelling with the utilization of stories as a designed teaching strategy to deliver content, to discuss post assignments, or to tackle negative feelings of frustration and of being overwhelmed. A narrative pedagogy goes indeed beyond the information dimension of learning and renders apparent the social basis of learning and knowledge.

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KEY TERMS

Community of Practice: First used in 1991 by Jean Lave and Etienne Wenger, the concept refers to the process of social learning that occurs among people who share a common interest in some subject or problem and are linked to each other over an extended period to share ideas, find solutions, and build innovations. The concept of community of practice has been recently associated with knowledge management and organizational development.

Computer-Mediated Communication: CMC is any form of communication between two or more people who interact via computer on the Internet. CMC mostly occurs through e-mail, chat, instant messaging, bulletin boards, list-servers, and MUDs (some also include audio and video communication). Today Wiki and Weblogs emerged as special forms of socially-oriented collaborative writing.

Content Analysis: This is a research technique based on the analysis of transcripts of interactions. Specific indicators are counted, classified, and interpreted as descriptive data to create an understanding of the content. It is a crossover technique that combines qualitative and quantitative methods. It includes the following phases: unitization, coding, inter-rater reliability tests, analysis and interpretation.

Social Constructivism: Social constructivism emphasizes the importance of culture and context in the process of knowledge construction. Learning is meant to be a social process that occurs when individuals take part in social activities. Instructional models based on this perspective stress the need for collaboration among learners and with practitioners in society.

Social Network Analysis: SNA has emerged as a new approach for understanding relationships among participants in an online learning environment. It serves to identify a set of structural variables such as density, connectivity, and heterogeneity that are implied in a network, and incorporates mathematical and statistical devices to measure individual positions within a network of participants.

Social Presence: Social presence was initially defined as the degree of other person salience in a mediated communication and the consequent salience of their interpersonal interactions. The term was soon after associated with the concept of media richness, according to which social presence is a quality of the communication medium itself. In more recent times, it has been redefined as the ability of participants in a community of inquiry to project themselves socially and emotionally, as "real" people, through the medium of communication being used.

C

Cooperative Learning Strategies for Effective Teaching and Learning Science Courses in Large Classes

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INTRODUCTION

Cooperative learning involves students working in groups on problems or projects such that it fosters positive interdependence, individual accountability, leadership, decision making, communication, and conflict management skills (Johnson, Smith, & Smith, 1991). Felder and Brent (1983) indicate that cooperative learning also enhances short-term mastery, long-term retention, understanding of course material, critical thinking, and problem solving skills. Recent literature suggests a number of cooperative learning strategies; however, many of these strategies may not be as effective or practical in large classes because of the larger number of students. Teaching a large class itself is challenging. Introducing cooperative learning strategies in large classes is even more challenging. Felder has described some innovative techniques including cooperative learning strategies for effectively teaching large classes. This article describes some other cooperative learning strategies that were used in large classes and provides results of student feedback on those strategies. The second section describes the results of a local survey on large class offerings in science education in some institutions in the western part of Nigeria. The third section describes cooperative learning strategies that were used inside or outside of a classroom. The results and conclusions are given in the fourth and fifth sections, respectively.

LARGE CLASS OFFERINGS IN SCIENCE EDUCATION

A survey was conducted to determine the prevalence of large class offerings in science education. The survey polled the school/faculty of science representatives to determine large science class offerings on their respective campuses. Campus representatives from six institutions responded to the survey. While the definition of a large class varies, 100 students were set as the threshold for a large class. Responses indicated that 98% of the responding institutions offer one or more science classes with 100 or more students. The class sizes ranged from 75 to 1000 with an average of 150 students. The largest class size in the other 2% of schools ranged from 18 to 75 with an average of 45. While only 98% of the institutions offer large science classes (n>100), the percentage of total students who attend such classes is much larger. Based on survey data, over three-fourths of students at reporting institutions attend large classes. Also, most of these large classes are offered in courses like general courses for computer science, mathematics, physics, integrated science, biology, and so forth.

This survey indicates that a majority of undergraduate science students attend large classes. Thus, improving the teaching-learning process in these large classes would have a significant effect on science education. Recent studies have confirmed that attrition rate among science students is higher during their initial years in college. Hence, improving large first and second year classes has potential for increasing science students' retention rates.

COOPERATIVE LEARNING STRATEGIES

Cooperative learning, as indicated earlier, involves group work. Groups may be organized along informal or formal lines. Wankat and Oreovicz (1994) define that informal cooperative learning groups are formed on the spur of the moment for a particular short term task and then dissolved. Such groups are useful in the middle of a lecture, to assign students a task such as solving a problem, answering a complicated question, or developing a question for the lecturer. Engendering a more cooperative class atmosphere, these groups serve as a break when the students' attention falters, and gives them a chance to practice team work. For the instructor, informal groups are a good way to start experimenting with cooperative learning.

After discussing a concept for about 15 to 20 minutes in a class, a multiple choice question is written on the board or displayed on the screen with a multimedia projector. Students discuss an answer to the question in an informal setting with neighboring students. The voice level during this one or two minute period goes up, reflecting the level of interaction and collaboration going on in the classroom. At the end of this period, all students are requested to raise a flashcard displaying a letter corresponding to an answer to the multiple choice question. The flashcard method allows active learning, collaborative learning, and 100% participation in large classes. It also allows students to assess how much they have understood and gives an instant assessment to the instructor about student understanding of the concepts just discussed. The multiple choice questions can be easily formulated to test knowledge and comprehension aspects of student learning as defined by the taxonomy in Bloom (1956). The taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation) provides a useful structure in which to categorize questions. A useful handbook on designing and managing multiple choice questions at all levels of the taxonomy was developed at the University of Cape Town, South Africa, and can be accessed over the Internet (Carneson, Delpierre, & Masters, 1997). Additional details on the basic flashcard method, without group activities, are given in Mehta (1995).

With the author's practical scenario experience with informal group activities, formal group activities were introduced in a large computer class. At the beginning of the semester, students were requested to provide their cumulative GPA, their grade in Calculus I (prerequisite class), the number of course credits they have registered for, and so forth. A composite index was determined based on the above information and was used to divide the class into three categories: top, middle, and bottom. Every student was given a letter code (x, y, or z) depending upon the category they belonged to. The students were not informed as to what the letter code represented or how the group codes were determined. This was done so that students do not feel either superior or inferior. In one of the class periods, in the last five minutes, students were asked to gather in three corners of the room depending on their codes, and groups of three students were formed by randomly selecting one student from each corner. This in itself proved to be a fun activity in the large class.

The students were assigned four group projects during the semester. Assigning three to four projects in a semester is ideal. Assigning more projects makes it difficult for students to meet often, as their schedules are usually full with several activities. The projects were chosen, so they can get acquainted with each other, recognize and appreciate their strengths and weaknesses in different areas, develop positive interdependence, collaborate to achieve a common goal, learn from each other, and also have fun. The four projects were:

- Performing throws of dices targeting six and determining their percentage success rate;
- Finding their learning styles and discussing similarities and differences in their learning styles;
- Generating a creative item like a joke, cartoon, or poetry, and coming to a consensus about which is the best item from their group, and
- Designing a optimum sorting technique algorithm.

The formal groups were encouraged to study together and prepare for examinations. The group members also took collaborative quizzes in the class. During such a quiz, the group members discussed how to solve a given quiz problem in the first three to four minutes. At that time, no writing was permitted. This activity greatly enhances their capabilities in problem solving, critical thinking, teamwork, and communication skills. In the next 15 minutes, they solved the quiz problem individually, just as in a regular quiz.

RESULTS

The students in the large computer class were asked for their opinion on integrating soft skills like cooperative learning (teamwork), active learning, problem solving, and critical thinking in all their courses. The

Table 1. Importance of integrating soft skills in academic courses

What is your opinion on integrating the following soft skills in your courses?

Soft Skills	Percentage Responses				
	A	B	C	D	E
Cooperative learning (teamwork)	39	46	15	-	-
Active learning	40	51	8	1	-
Problem solving	57	40	2	1	-
Critical thinking	59	36	4	1	-

Scale: (A) Very Useful, (B) Useful, (C) Neutral, (D) Not Useful, (E) Not Useful At All
* Number of responses = 95, Student Enrollment = 101

Table 2. Usefulness of specific strategies

Please rate the following strategies in terms of learning the subject matter or fostering soft skills.

Strategies	A	B	C	D	E
Informal in class group activities	42	42	15	1	-
Dice throwing	3	39	28	11	8
Creative exercises	11	36	28	18	7
Learning style exercise	9	53	23	12	3
Sorting algorithm design	54	36	7	2	1
Overall, formal group projects	11	52	26	12	-
Group discussion before the quizzes	75	23	2	-	-

Scale: (A) Very Useful, (B) Useful, (C) Neutral, (D) Not Useful, (E) Not Useful At All
* Number of response = 95, Student enrollment = 101

results are shown in Table 1. They indicate that between 85–97% of the students believe that the integration of soft skills into their courses is either very important or important. The students considered problem solving (97%) and critical thinking (95%) skills to be of most importance.

The students were then asked to rate the specific activities (done in the computer class) regarding their usefulness in either learning the subject matter or fostering soft skills. The results, given in Table 2, show that informal group discussions inside a classroom were perceived to be very useful or useful by 84% of the students. On the other hand, formal group projects done outside the classroom were perceived to be very useful or useful by only 62% of the students. Among the four specific projects, the throwing of die and creative exercises were perceived to be very useful or useful by only 42% and 47% of the students, respectively. The optimal design of the sorting technique algorithm was perceived to be very useful or useful by 90% of the students.

The group discussion by the formal group members before the quizzes was perceived to be very useful or useful by 98% of the students. This particular result is amazing; it does not require any additional effort by an instructor, and it fosters problem solving, critical thinking, collaborative learning, and communication skills. The collaborative quizzes still show variations, suggesting that the individuals who understood the subject matter do better than others who are ill prepared. The preliminary comparison of collaborative quizzes and regular quizzes indicates that the average scores ($m = 7.80$, $s = 2.01$, $n = 595$) in the collaborative quizzes are slightly higher (statistically insignificant at the 0.05 level) compared to the average score in the regular quizzes ($m = 7.74$, $s = 2.41$, $n = 609$). However, not everyone is receiving high scores. This does show accountability in terms of individual understanding of the subject and preparedness. More detailed analysis is being done to see the effect of collaborative quizzes on the top, middle, or bottom thirds of the class.

CONCLUSION

The survey indicates that large classes are prevalent in science education. However, the good news is that large classes can be made more effective by implementing suitable strategies. This article describes formal and informal group activities to foster soft skills like problem solving, critical thinking, cooperative learning, and communication. The methods described in this article, especially the flashcard method, a design project by a group, and collaborative quizzes, do not take a significant amount of instructor time or resources and are effective in large classes.

Several other strategies like daily homework, daily attention quizzes, and quick feedback on the Web were also incorporated in this large class (Mehta & Schlecht, 1998). The attendance in the class ranged from 85–98% which is much higher than the average large class attendance reported in the literature (Romer, 1993). Students were asked to rate learning in this class compared to learning in other classes on a scale of (A) very good to (E) very poor. Overall, 97% of the students indicated that learning in this class was very good or good compared to learning in other classes.

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KEY TERMS

Communication: The use of protocol for data transfer or signaling by putting synchronous or asynchronous data streams into channels.

Computer: Computer is a device that can perform arithmetic and logical operations on data and provide the results of its operations automatically without any human intervention.

Education: The development of every aspect of the personality, intellectual, physical, and moral to its fullest potential.

Learning: Using search capabilities, rich interaction, and tracking of information contents through formal or informal teaching methods.

Teaching: Discharging accessible resources for effective learning and performance-based assessment.

Cyberspace's Ethical and Social Challenges in Knowledge Society

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INTRODUCTION

During the last years the issue of *digital divide* has received particular attention from international bodies like the UN, UNESCO, OECD (Bindé, 2005; OECD, 2001; UN, 2006). These organizations acknowledge that our planet is divided into "information haves" and "information have-nots" and that the effort to bridge this global gap is one of the main challenges of society today.

Interest in digital divide is also widely present in literature. In these last five years, research and empirical surveys on this subject have notably increased (Baker, 2001; Hargittai, Di Maggio, Neuman, & Robinson, 2001; Ranieri, 2006; Rallet, 2004; Sartori, 2006; van Dijk, 2005).

What does digital divide mean? What are the causes of the digital gap? How can education and technological research contribute to facing this challenge?

In this chapter, we shall first develop this concept, identifying through literature reviews its dimension and causes. We shall then focus our attention on the possible roles that education and technological research can play in order to overcome the gap, suggesting four main directions to be followed, with the help of concrete examples.

DEFINING DIGITAL DIVIDE: A LITERATURE REVIEW

The *Oxford English Dictionary Online* (2004) registered the first occurrence of the term "digital divide" in an article published in 1995 in the *Columbus Dispatch* (Ohio), giving the following definition: "the gulf between those who have ready access to current digital technology (esp. computers and the Internet) and those who do not; (also) the perceived social or educational inequality resulting from this."

Still during the mid-1990s, the term recurred in the reports of the U.S. National Telecommunications and Information Administration (NTIA) regarding the inequality of access to telecommunications. NTIA published six reports from 1995 to 2004 in a series entitled *Falling through the Net*. In the third NTIA report (1999) the profile of the *have-nots* was introduced and defined, and the following five different levels of inequality in Internet usage were identified: (1) between the minority of connected and the majority of unconnected; (2) between those who use the Internet for a wide range of activities with advantageous effects and profit and those who do not use the Internet; (3) between those who can use paid services and those who use the Internet's free research engines; (4) between those who use the net for e-commerce and those who do not effect any transactions on the Internet; and (5) between those who benefit from the broadband and those who cope with only slow connections.

In the following years the term became a very commonly used expression in European debates and eventually extended also to the developing countries. Some authors underline the ambiguous character of the term *digital divide* which is a very wide concept (going from access and non-access to telecommunication infrastructures and educational programs) used in reference to most diverse situations involving nations, regions, organizations, social groups, individuals, and so forth (Rallet & Rochelandet, 2004; Yu, 2002).

In the attempt to clarify it's meaning, three different accentuations can be identified in debates and in literature.

Initially, the accent was placed on technological equipment, and digital divide was conceived as a form of exclusion of those who did not have access to the information and communication technologies (ICTs).

A wider perspective enriches the semantic range of the term with other meanings. This vision is based not only on having or not having of the ICTs, but on the effective ability to use them. In this perspective, it is not important to increase the number of technological equipment and Internet connections, but to evaluate and improve their uses. If we considered the contextual, cultural, and knowledge resources available to individuals and groups, digital divide would therefore be the consequence of pre-existing inequalities and defines the gap between the ICTs users and those who do not use them. It would moreover be legitimate to speak not only of digital divide but also of digital inequality referring to the social and knowledge gaps that influence the diffusion and adoption of technologies (Sartori, 2006).

A third approach focuses on contents (knowledge, information, expertise) and the services to which the ICTs give access, independently from the technologies. Digital divide is therefore defined as the gap between those who have access to contents and services offered by the Internet and those who do not.

More generally, according to Baker (2001):

> The digital divide can be conceptualized from a *user* standpoint as a suboptimal condition of access to technologies (the initial conceptualization of the digital divide), orientation on hardware, networking, and access to advanced IT/Telecom services:
>
> - Content available, that is, what services and information can be accessed and
> - Utility/awareness which relates to the actual value as well as the perceived value or awareness of the user/citizen/business of the use of ICTs and associated services.

The definition proposed by the OECD and to which the most part of studies refer, includes the various elements highlighted up to now: "the gap between individuals, households, businesses and geographic areas at different socioeconomic levels with regard to both their opportunities to access ICTs and to their use of the Internet for a wide variety of activities. The digital divide reflects various differences among and within countries. The ability of individuals and businesses to take advantage of the Internet varies significantly across the OECD area as well as between OECD and non-member countries" (OECD, 2001, p. 5).

In synthesis, according to this last definition the concept of digital divide is applied on a universal level, goes back to various geographic dimensions (international and intranational) and includes two distinct problems, that of access and use of the ICTs, and is ultimately conditioned by access to the resource infrastructures.

UNDERSTANDING DIGITAL DIVIDE

Digital divide is a multidimensional phenomenon. In order to examine the factors influencing its evolution, it would be useful to distinguish between two different levels of analyses: a macro analysis level, aimed at globally identifying the diverse economical, social and political conditions which characterize industrialized and developing countries; and a microanalysis level, aimed at evaluating the individual characteristics of Internet users (Sartori, 2006, p. 51).

The comparison between the industrialized and the developing countries shows that elements like income, education and training, investments in the sectors of research and development, and the costs of infrastructures, are crucial factors that can prevent or facilitate the diffusion of the Internet in various countries. An effective comprehension of the phenomenon is in fact possible only by integrating the various elements.

Let us start from the first factor. The degree of development of a country is certainly a decisive factor. For example, in observing trends in the map showing the extent of the use of the Internet by countries, we can see that its coverage goes hand in hand with geographic development. In other words, there is a close relationship between inequality in industrial development and inequality of access to information (Bindé, 2005). However, the wealth of a country, as fundamental as it can be, is not sufficient in itself to increase the use of the Internet (Norris, 2001).

Besides, digital literacy is fundamental. The international organizations agree that it constitutes, along with the educational background and the knowledge of languages, a prerequisite that can positively or negatively influence access to the Web.

In addition, the factors related to offers of new technologies are to be considered. Availability of infrastructures and the costs of computers and connections have a direct impact on the opportunities of individual users to access the Web. The costs are still very high especially in developing countries, where they are higher than in developed countries (Bindé, 2005).

Obviously, directives from local governments regarding public policies in the ICTs sector also affect costs. They can more or less be oriented towards the liberalization of services to favour greater competition between the *providers* with the consequent reduction of costs for the single user, or in support of a major intervention of the state and international organizations in defining tariff policies. The debate on the most effective policies to adopt for cost reduction is, however, still underway (Rallet et al., 2004).

An additional dimension to consider on the macro level is the relationships between politics and Internet, whereby some governments enact preventive censuring measures by filtering the information resources available and reducing universal access to information.

Going on to consider the differences between individuals and social groups, the main factors of access inequality are to be traced to family and individual income, age, degree of instruction, gender, language, residential geographic areas, professional status, and the physical-psychological abilities of the people involved (Bindé, 2005).

As mentioned earlier, the *costs* of computers, software, and connections can be discriminating for individuals and families with low income, both on the global and local level. Along with income, age can represent an obstacle when considering single users. The youth are often avant-garde in technological innovation and their applications, but are also more exposed to economic and social problems. As to the elderly people, the possibility of their education on the use of new technologies could be impossible due to the lack of specific training courses.

Besides age, *gender* also holds a relevant importance. Inequality between men and women in the face of new technologies constitutes another feature of digital divide. Almost two-thirds of the world's illiterate are women. In the developing countries, an average of one out of two women, is illiterate. If in the industrialized countries women represent a consistent part of the Internet users, there is a very high risk that in the developing countries women may accumulate disadvantages, thus losing almost all possibilities of access to the Net.

Another barrier is the affirmation of English as the language vehicle of globalization, leaving no room for other languages in World Wide Web. Together with language, educational, and social-cultural backgrounds play a most meaningful role in favouring or not, access to the Net. In the future, the post-industrial societies may require great investments to favour education and training, with the objective of reducing educational barriers, and cultural and linguistics gaps (knowledge gaps) that make the Internet an inaccessible goal for those populations living at the margin of globalization processes.

Another factor of inequality regards asymmetry between urbanized areas and rural zones. The latter, especially in developing countries, has remained excluded from the digital revolution that has taken over the urbanized areas. The nomadic technologies can offer great opportunities to allow the rural zones to move out of their isolation but their diffusion in these areas is still insufficient.

Ultimately, another element to be considered regards individuals with disabilities. The most part of ICTs results to be scarcely accessible, thus producing the exclusion of a great part of users with special needs. The ICTs instead could devise for these people, instruments which will allow them to participate in social life, continue to carry out their work activities and have access to training experiences.

THE ROLE OF EDUCATION AND TECHNOLOGICAL RESEARCH

How should digital divide be faced? What contributions can education and technology offer to face this problem?

Current literature shows a wide agreement on the importance of interventions in the area of training and education, in reducing the digital gap between individuals and social groups, either by offering free access to technological equipment or by delivering computer literacy programs. On the technological level, the adoption of open source approaches and investments in research geared towards enabling technologies are emerging as the most suitable solutions in the long run, especially in civil society. We here present some initiatives.

The Internet as a Public Service

The availability of public access to the network represents a preliminary condition in allowing economically disadvantaged individuals to make use of the ICTs. The Internet should be considered as a "public information service and not only as a commercial product" (Beccalli, 2004, p. 113).

Therefore, well-equipped schools and libraries can play an important role. They can in every way take part in solving the problem also for the countries of the OECD area, as already indicated in the 1995 NTIA report. In the industrialized countries many interventions have been implemented to this end.

In the developing countries the experiences of the Community Multimedia Centre (CMC) and the communitarian telecentres, have been significant (Guttman, 2003). The creation of the CMC was promoted in the last years by UNESCO. The CMC combines the use of local radios with that of computers connected to the Internet, e-mail, faxes and photocopy engines. Besides being free of charge and allowing shared access, the CMC experience is characterized by the notion that a relevant contribution to solving digital divide can be offered through the oldest media like books, radio or television. Old and new technologies do not substitute for one another, but are complementary. The former effectively contributes to the diffusion of knowledge by facilitating access to the latter.

The communitarian telecentres promoted for example by the Brazilian administration, are free-of-charge public centres in which people can access computers, printers, Internet, and so forth. One of the features is their location in peripheral and disadvantaged zones, and are autonomously self-managed by the community. There are already a number of examples of such structures globally, especially in Latin America, the Caribbean and Africa. They are often equipped with free software. Besides the lowering of costs of licenses, the use of free software allows the use of hardware that is not of the last generation, recovering in this way, the resources which would otherwise be lost. In addition, the opportunity to access the source code of the software enables technicians to intervene autonomously in technological problem solving and in the subsequent implementation of software, thus starting off a process which will also be sustainable in the long term.

Open Software and Content

As seen in the Brazilian experience with telecentres, the adoption of open-source software may constitute a crucial mean for equal opportunity to access. It promotes a kind of digital solidarity fundamental to bridging the technological gap. As observed by Berra and Meo (2001):

Through a modifiable technology distributed at low prices, if not free of charge, it would be possible to concretely conceive policies that can limit the social and geographical discontinuities in their diffusion and use. [...] The dream of reducing the "technological gap" seems to be more easily fulfilled through the diffusion of open-source software rather than by the world-scale extension of closed-source software produced by the big monopolistic industries.

As commonly known, free software is based on the freedom to modify the program according to one's own needs, and to distribute the modified versions so that the community may profit from the improvements implemented (Stallman, 2003). Thanks to this, free software is proving to be a solution that is particularly suitable to the contexts in which there is need to control the technologies used, the resources are limited, and it is necessary to find specific solutions.

The "openness philosophy" and software-sharing practices are also growing in the educational field. In the Internet there are a great variety of open source software (often free of charge) for education, that is, educational software, content management system (CMS) and/or learning management system (LMS) like for example Moodle, blog, wiki, and so forth.

While the open source regards the software, the open content adopts its philosophy but applies it to products like Websites, music, films, photographs, literature, and also educational contents. In this case, the author preserves the work's copyright, but allows its use by third parties under an open content license. There are various types of open content licenses. Usually the users can copy, publish and redistribute the work, provided that attribution is given to the original author and all modifications to the work are identified. The advocates of open content believe that the availability of free contents promotes collaborative work and contributes to increasing knowledge while reducing individual efforts. In addition, open content in education allows the improvement of instructional materials, and facilitates its reuse and adaptation. One of the most important initiatives is the Open Course Ware program promoted by the Massachusetts Institute of Technology (MIT). The program which began in 2002, provides free online access to educational course materials and contents. In the same year UNESCO introduced the term "open educational resources" at the Forum on the Impact of Open Courseware for Higher Education in Developing Countries.

Enabling Technologies

An ulterior step could be the development and implementation of technologies aimed at satisfying the needs of various global users, and therefore favouring and funding researches to this end. The design and implementation of innovative technologies more oriented towards the demands of currently excluded users, formulated in their tongue and distributed at low costs, could moreover find a market which is ready to receive them.

An example is the Simputer, a device which supports the functions of a PC, but in a simpler way. The Simputer does not need a keyboard and allows the user to interact with the PC by touching the screen to send commands and listening to its answers (vocal messages).

If the Simputer responds to the need of developing technologies enabling illiterate people in developing countries, the project *One Laptop per Child*, promoted by Media Lab of MIT in Boston, represents an effort to find enabling solutions for people living in zones without electricity, or wherever saving energy results to be important or decisive. Negroponte, Director of Media Lab, on the occasion of the second session of the World Summit on Information Societies (Tunisy, 2005), demonstrated the prototype of a laptop costing $100, that could allow thousands of children in developing countries to use a personal computer, thanks to expedients that reduce energy consumption and a lever device that can temporarily recharge the batteries.

Promoting Digital Competence

Access to an education, which includes computer literacy in the curricula, ultimately plays a crucial role. The European Community for example, has moved in this direction during the last five years. The Lisbon European Council (2000, March 23-24) emphasized that "Every citizen must be equipped with the skills needed to live and work in this new information society" and that it is therefore necessary that "a European framework should define the new basic skills to be provided through lifelong learning: IT skills, foreign languages, technological culture, entrepreneurship and social skills."

The ICT skills are expressly indicated by the Council of Lisbon as a basic skill. Coherent with this purpose, the key competencies framework was redefined, changing the number of required competencies from three to eight and including "digital competence" as one of the five new competencies. In the definition of this competence, it is pointed out that, "Digital competence involves the confident and critical use of electronic media for work, leisure and communication. These competences are related to logical and critical thinking, to high-level information management skills, and to well-developed communication skills. At the most basic level, ICT skills comprise the use of multi-media technology to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in networks via the Internet" (European Union - Working Group B "Key Competences", 2004, p. 7). In other words, digital competence does not only include the simple procedural skills, but also encompasses high-level abilities in logical and critical thinking, information management, and communication.

Moreover, in the field of initiatives undertaken to promote online education, the European Council Parliament started off the *e-Learning* program (2004-2006), to stress the need "to address the problems of social exclusion resulting from the inability of some individuals to take full advantage of the benefits offered by information and communication technologies (ICT) and the Internet in the knowledge society, the so-called "digital divide" which often affects young people, the disabled and elderly, and social categories who are already victims of other forms of exclusion". The program provides as frontline action the promotion of digital literacy. Action in this field must cover both conceptual and practical issues, from the understanding of digital literacy to the identification of remedial actions for specific target groups: "Digital literacy is one of the essential skills and competences needed to take an active part in knowledge society and the new media culture. Digital literacy also relates to media literacy and social competence, as they have in common, objectives such as active citizenship and the responsible use of ICTs." (Decision No 2318/2003/EC of the European Parliament and of the Council of 5 December 2003).

Two meaningful trends emerge from these recommendations. The first regards the need to promote educational programs on ICTs based on a wider concept of computer literacy. It should include not only procedural skills (as contemplated in ECDL), but also and above all the critical use of ICTs in daily life. This is also coherent with the concept of computer literacy suggested by ETS (2004), which developed a framework for ICT Literacy at international levels, commissioned by OECD.

The second concerns the currently emerging relationship between media/digital and social competencies: if citizens are to exercise a real citizenship in Knowledge Society, they must be enabled to read the new alphabets, decode the new languages, and the "cognitive citizenship" which both media and digital competencies help to acquire

CONCLUSION

Digital divide is one of the most urgent challenges today. In a world where information and knowledge represent an indicator of wealth, the exclusion from electronic networks within which these goods circulate, results in evermore-dramatic forms of social and cultural exclusions.

Educational systems and technological researches can contribute to facing the problem by:

1. Providing public access to ICTs
2. Adopting open approaches to ICTs and content delivery
3. Promoting technological research, oriented towards design and implementation of enabling technologies
4. Implementing educational and training actions in order to develop digital competence.

An area of great interest in the educational field is the designing of programs aimed at developing the ability to benefit ICTs in a critical way. Such a vision involves the notion of digital competence, which surpasses the traditional concept of computer literacy advocated by the ECDL and certainly opens out to new challenges in educational research.

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KEY TERMS

Digital Competence: Digital competence involves the confident and critical use of electronic media for work, leisure and communication. These competencies are related to logical and critical thinking, high-level information management skills, and well-developed communication skills.

Digital Divide: "The gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access ICTs and their use of the Internet for a wide variety of activities" (OECD, 2001, p. 5).

Open Content: As indicated in Wikipedia, this term "describes any kind of creative work (including articles, pictures, audio, and video) or engineering work (i.e., open machine design) that is published in a format that explicitly allows the copying and the modifying of the information by anyone […]" (Retrieved July 30, 2007, from: http://en.wikipedia.org/wiki/Open_content).

Open Educational Resources (OER): Refer to "educational materials and resources provided freely and openly for anyone to use and under some licenses re-mix, improve and redistribute." Open educational resources include learning content (i. e., course materials, learning object, documents etc.), tools (i.e., software for creation, delivery, use and improvement of open learning content) and implementation resources (i.e., intellectual property licenses) (Wikipedia. Retrieved July 30, 2007, from: http://en.wikipedia.org/wiki/Open_educational_resources)

Open-Source Software: A computer software with a source code available under a license that allows users to change and improve the software, and to redistribute it in modified or unmodified form. It is often developed in a public and collaborative way.

Simpute: An acronym for "Simple, In-expensive, Multilingual, People's Computer". It is a small hand-computer, designed and implemented for use in developing countries. The device was designed by the non-profit organization, Simputer Trust, founded in 1999.

Data Caching Patterns

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INTRODUCTION

As information technology (IT) has become part of business in today's globalized economy, increasingly higher performance of information systems is demanded by the business models to support various business operations and help the business compete and succeed. IT must strive to be nimble and adaptive to provide a higher level of services and, at the same time, reduce the total cost of ownership (TCO). In most situations, the current enterprise infrastructure must be extended to get the most out of the existing investments. Creating innovative solutions is an effective approach to achieve this goal, and scalable data management is one of the most valuable innovations.

BACKGROUND

Definition

In general, a data cache is defined as a data block that contains frequently accessed contents in a text or binary format. A persistent data block is saved in storage at either the client or the server side. Alternatively, a transient data block may be stored in a memory buffer for the lifetime of an application, a user session, or a single-client request. Caching is a widely used technique to boost the performance of data access. When a program needs to access a particular data element, the process first checks the data cache to verify whether the element has been previously retrieved and stored. If a match is found, the application will use the data directly from the cache, rather than accessing to the data source again. As a result, a drastic performance gain is realized, since the data access in RAM is significantly faster than that to a disk or external resource over the network. In addition, a cached data element is usually in a ready-to-use form, so that little or no transformation and initialization is needed, resulting in higher performance in the processing.

Value Proposition

Generally speaking, many performance challenges may be resolved via the horizontal or vertical scaling. Extra servers are added in the horizontal scaling. The vertical scaling approach upgrades the existing machines with more and faster processors, additional memory, larger hard disks, and/or higher-speed network connection. In today's competitive environment, however, the ultimate challenge is a balance of the overall project cost and on-demand scalability to meet the capacity needs. Without looking into the end-to-end performance chain, particularly at the application software level, simply investing more on hardware alone usually does not fix the root cause despite the fact that it may temporarily alleviate the symptom. In other words, a more holistic approach should be taken to improve the overall architectural design. The best solution to systematically address the performance issue is usually an aggressive use of data caching technology.

DATA CACHING PATTERNS

A wide range of caching patterns can be applied individually or in combination as a means to increase application performance. Each pattern was designed with its own specific merits and addresses a certain type of data access issues. Classifying data caching patterns is a challenging task, resulting in a different outcome scheme based on the criteria applied. For example, they may be categorized as creational, structural, and behavioral. Alternatively, they may be grouped at the levels of the method, class, component, application, platform, and system.

A vast majority of today's distributed applications are developed in either Java or .NET on an n-tier architecture, which consists of a series of logical/physical layers: client, Web, application, integration, and data and enterprise resource. Accordingly, a taxonomic scheme is defined in Figure 1 to sort various caching patterns into appropriate layers. Furthermore, those patterns that can be used in multiple layers are grouped in the cross-layer category.

Client Layer

AJAX

Asynchronous JavaScript and XML (AJAX) is a Web development style in which small chunks of data in XML format are transferred from the Web server in an asynchronous manner behind the scene. As a result, a responsive interaction on the Web page is realized because there is no need to reload the entire Web page every time a user clicks a link or button on the page. In the AJAX model, the browser caches a great deal of data, and other blocks of data can be asynchronously retrieved from the servers in an on-demand or proactive fashion.

Cookie

Client-side cookies may serve as a data cache, which acts just like the hidden input fields in HTML. Persistent cookies can save the data permanently on the local hard drive of the client machine. Session cookies store the data elements temporarily in the memory, but the data contents will need to be set just once, unlike the hidden fields that have to be set by the server-side in each response. In the scenario where multiple systems collaborate to provide a service by transferring controls between each other, a cookie is a viable approach to storing the session data. However, the cookie data are sent to the server from a browser in every http request, which still generates a tremendous amount of network traffic. In case the originator sets the domain attribute, the cookie contents are invisible to other Web sites. Under the circumstance where a user opts to switch off the cookie option in the browser settings, this technique becomes worthless.

It is recommended in RFC 2109 (Kristol et al., 1997) that at least 4096 bytes per cookie are implemented, which is the size limit placed by most browsers in the market. The future browser versions tend to support 8192-byte size cookies.

DNS Resolver

The DNS lookup results may be cached to minimize query calls to the DNS server. Popular Web browsers implement the client DNS resolvers with cache. The Mozilla browser caches the DNS host entries for 15 minutes, whereas the DNS cache expiry time is set to 30 minutes in Internet Explorer (Microsoft Support, 2004).

Hidden HTML Frame

Data elements may be cached in a hidden frame in an HTML page on the client browser, which eliminates the roundtrips to the server—an inherent attribute in the hidden field pattern. Client-side scripting can be leveraged to access the data stored in a hidden frame. This method only requires the client-side resources because the data elements in the hidden frame are stored and retrieved locally from the page on a browser.

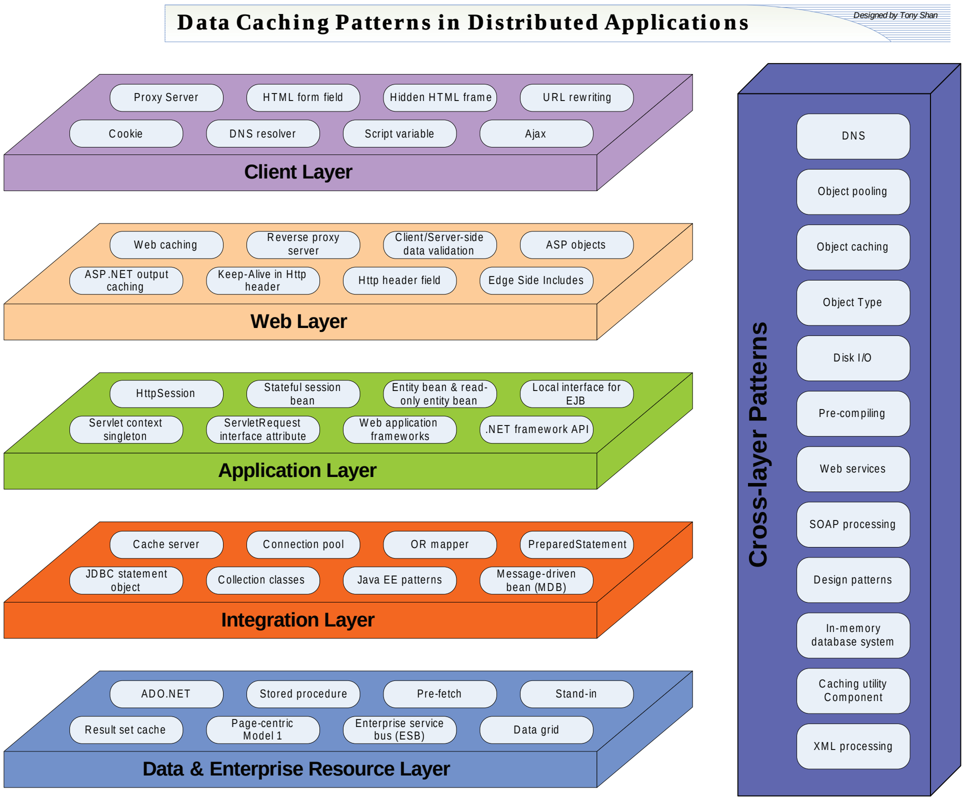
HTML Form Field

Session-related data may be stored in the hidden input fields in an HTML form. This pattern is server technology agnostic, and the hidden-field data elements may be submitted to other Web sites in addition to the original Web site that set the contents. On the other hand, the exact same chunk of data elements must be transferred back and forth between the browser and server in every hit, adding extra network bandwidth consumption in the communications. Special encoding/decoding must be implemented for binary data, via encoding schemes like *Base 64*. Moreover, the names and values of the hidden input fields may have to be scrambled or encrypted to restrain the possible hacking attempts.

Proxy Server

A proxy server is an appliance made up of software or hardware that enables indirect connections from applications to other network resources. For a dynamically constructed Web page, only changed blocks of data are sent, so that the network bandwidth consumption is significantly reduced.

Figure 1. Data caching patterns



Script Variable

The variables in the JavaScript or VBscript embedded in a HTML page can be used to store cached data. In this way, the data elements can be centralized in one place, rather than replicated as hidden input fields in all the forms in a Web page.

URL Rewriting

In URL rewriting, caching data elements are embedded as a part of the URL request string in a session. The constraint is that only HTTP GET method can be used to send requests to the server. In terms of the URL length limitation, most browsers impose a cap, even though no specification requirement is defined in RFC 2616 (Fielding et al., 1999). The Microsoft Internet Explorer browser, as an example, restricts the number of characters in URL up to 2083 (Microsoft Support, 2006).

Web Layers

ASP Objects

Active Server Page (ASP) technology (Microsoft Knowledgebase, 2004) has two objects that can be used to cache key/value pairs in memory: *Session* and *Application*. The primary difference between these two objects is the scope. The data stored in a *Session* object is for a single user across multiple requests, whereas the *Application* object stores per-application data to be used by multiple users.

ASP.NET Output Caching

A coupe of new kinds of caching capabilities were added in the ASP.NET technology, namely output caching at the page level and user-control level (fragment caching).

Exhibit A.

```
<meta HTTP-EQUIV="Pragma" CONTENT="no-cache">
<meta HTTP-EQUIV="Cache-Control" CONTENT="no-cache">
```

Exhibit B.

```
<% Response.AddHeader "Pragma", "no-cache" %>
<% Response.CacheControl = "no-cache" %>
<% Response.Expires = -1 %>
```

Client/Server-Side Data Validation

It is almost always required to validate the user input data before invoking business logic. In case the input data contains an error, the data validation can detect the data problem and avoid hitting the backend server needlessly. In Microsoft .NET technology (Microsoft .NET, 2005), the IIS server has the intelligence to determine in real time whether to push the data validation logic to the client side or leave it at the server side. In general, the data validation logic and reusable data blocks are generally dispatched to the client side for rich client applications in favor of performance enhancement. This also applies to partner applications using Web services communications. However, this means that a tremendous amount of data and logic is replicated to a large client base. It is noteworthy that pervasive computing devices like Blackberry most likely have insufficient space to cache a large portion of data.

Edge Side Includes

JSP fragments can be cached using custom tags, which has been increasingly used by applications. The cached contents are produced with the body of the tag, which can be either the display view or the values computed for variables. The JSP Tag Library for Edge Side Includes (ESI), or JESI (JSR-128, 2004), defines a custom tag library that automates the generation of the ESI code in the JSP syntax. ESI is a markup language for partial page caching of HTML fragments (ESI, 2001).

HTTP Header Field

Even though the cache data may be contained in an Http header field for a session in some situations, it is discouraged to take advantage of the header to store any data related to the business logic, following the design principle of loose-coupling between layers in an application.

Under some circumstances, such as stock quotes, it is undesirable if the browser caches the display output. A mechanism is defined in the HTML specification (Fielding et al., 1999) to notify the browser that it should not cache the information so that it retrieves the up-to-date information from the server each time the URL is requested.

The code snippet in Exhibit A can be included to mandate no caching between the <Head> and </Head> tags in a HTML page.

The first line works in HTTP Version 1.0, while the second line is for Version 1.1. This ensures that the data are uncached in the browser so that fresh data are always retrieved from the server to serve the client's request.

The no-caching information can be alternatively transmitted via the Http header. The code segment in Exhibit B is for ASP applications.

The last line prevents caching at the proxy server. In addition, the same effect can be realized programmatically in Java Enterprise Edition (EE) applications, utilizing the setHeader(), addHeader(), and setDateHeader() method of the Response class in the JSP and Servlet code, for example see Exhibit C.

Keep-Alive in Http Header

To reuse the socket connection established between the browser and Web server after the first http hit, the connection can be persistent for subsequent requests by a special header in Http 1.0.

Reverse Proxy Server

A reverse proxy serves as a front end of different backend servers. It delivers Web contents in a single URL

D

Exhibit C.

```
<% response.setHeader("Pragma", "no-cache");
   response.setHeader("Cache-Control", "no-cache");
   response.setDateHeader ("Expires", 0); %>
```

from a group of Web servers that are implemented in different architectures and platforms. Be aware that an SSL/TLS connection does not extend across a reverse proxy transparently, because the connection to the browser is terminated by the reverse proxy. Therefore, the connection is fully controlled by the reverse proxy, including the authentication information in the header fields. A reverse proxy can be used to balance the incoming loads or replicate contents to areas that are dispersed geographically. However, the limitation of a reverse proxy is its scalability since it is not intended for optimized caching.

Web Caching

Web caching is the caching at the Web layer that accelerates the delivery of static contents such as HTML files, images, CSS, scripts, and multimedia contents. The use of the view elements generated from the application layer is optimized. Consequently, the delivery of nondynamic contents is considerably improved.

Application Layer

.NET Framework API

A rich set of data caching APIs are offered in the Microsoft .NET framework, which provides an in-memory, application-scoped, thread-safe space that can hold any serializable object or object collection. There are two data caching classes in the System.Web: Caching namespace: *Cache*, used to add and remove data elements in the cache, and *CacheDependency*, used to define a cache dependency to a data element in the cache store.

The method *Insert()* has the time-based expiration built-in, either absolute or sliding time invalidation. A callback function to a cached item can be implemented, which will be automatically invoked at the time that item is deleted form the cache store.

Accessing EJB via Local Interface

In early Java EE specifications, EJBs must be accessed via a remote interface only. The later EJB versions (EJB 2.0 above) allow the beans to be accessed via a local interface.

Entity Bean

An entity bean is used for data persistence, while a session bean usually implements a use case. The caching of entity beans in an EJB container can be directly leveraged when the components run in a single application server. In a load-balanced environment for high-availability systems, however, a cached entity bean is likely updated by another copy of this entity bean in another instance. As a result, the beginning of an invocation should always call the ejbLoad() method to ensure that the current state is loaded. As compared with other lightweight data persistence approaches such as the DAO pattern and Object-Relational Mapper (ORM), the entity bean component model incurs significant overheads in the runtime. Therefore, this model is replaced by the Entity class in the Java Persistence API, which is part of the Java EE 5 standard.

Read-Only Entity Bean

Some EJB container vendors implement read-only entity beans, which allow caching of entity beans that are unchanged in its life cycle, indicated in the vendor-specific caching attribute of the deployment descriptor. A nonstandard API to invalidate cached beans may be provided by vendors. Read-only entity beans are proprietary and not portable, and they are not supported in the EJB 3.0 specification (JSR-220, 2005).

HttpSession

In a Java EE application, the HttpSession class (JSR-154, 2006) contains a good number of APIs to store extraordinarily complicated data structures for a particular browser session. As a matter of fact, HttpSession is implemented via an in-memory replication or a persistent database by most Servlet containers. Retrieving data from the HttpSession object is much faster than from the original data store. Be aware that there is just one HttpSession object that exists between a Servlet container and a browser. The HttpSession object is a "global" container to the Servlet applications running in the same container. Occurrence of a collision is possible if the same data elements are modified or retrieved by the user session accessing multiple Servlet applications on the same Servlet engine.

The default value for session timeout is usually 60 minutes. To effectively use the cache space, manual invalidation of the session and clean the caching items are highly recommended, as the garbage collection by the container takes unnecessarily longer time.

Servlet Context Singleton

The singleton design pattern is implemented in the Servlet Context, where all Servlet requests can be cached. The Hashtable collection class is usually used for singleton cache design, which sets no limit in size and is thread-safe. However, it, like HttpSession object, has a similar collision issue. Another disadvantage of this approach is that the Servlet container does not manage this resource.

Attribute in ServletRequest Interface

The ServletRequest interface offers a way to cache data elements via attributes in the request object. The data structure of attributes is name-value mapping, where a name is an index and a value is a generic Java object. The *setAttribute()* and *getAttribute()* methods can be called to manipulate the attributes in the request that is forwarded to another handler or Servlet. It is worth noting that the attributes are reset between requests submitted to a Web server. This technique often used along with the *RequestDispatcher* object.

Stateful Session Bean

A fairly small amount of data may be cached in a stateful session bean in a user session, which takes advantage of the built-in cross-server session replication capability by the clustered servers. One pitfall that one needs to be cautious about is that the scalability of stateful session beans is a challenge for large-volume systems, and overheads of the bean management in the container may become an issue.

Web Application Frameworks

Almost every Java Web application framework, such as Struts (Struts, 2006), JavaServer Faces (JSR-252, 2006), and Spring (Spring, 2006), caches client session data at different levels: request, session, and application. This data caching feature can be directly leveraged for the applications built on top of these frameworks. For instance, the struts-config.xml file in Struts specifies the scope of data elements in an ActionForm bean declaratively.

Integration Layer

Cache Server

A dedicated integration server or middleware like message queues may be used for application/business integration in distributed systems. Business process servers usually run the process orchestration and long-lived transactional processes. Both volatile and nonvolatile data may be cached in this layer. A stand-alone cache server is also useful, particularly in the scenarios where distributed caches are implemented. A cache server also plays a role as a stand-in to backend databases and legacy systems, offering better availability.

Collection Classes

It is crucial to utilize appropriate collection classes to represent application data structures in a distributed system. Misuse of standard collection classes simply wastes the resource and incurs unnecessary overheads. In the case where thread-safety is not required, Java Hashmap ought to be used in place of Hashtable, resulting in improved application performance. The best practice is to select the attribute collection that has the narrowest scope to meet the technical requirements.

Connection Pool

It is a very common practice to share expensively-created connections via a connection pool, such as SSL and database connections. The application servers that are compliant with the Java EE 1.3+ all have the data source built-in, which should be used for database access, rather than writing custom connection pooling. Alternatively, a connection pooling component is available in the Apache Jakarta Commons package (Apache Jakarta Commons, 2005).

Java EE Patterns

Value Object (Alur, Crupi, & Malks, 2003), or Transfer Object, is a useful pattern to minimize the *get()* method calls to obtain attribute values from an enterprise bean. A value object class is an arbitrary serializable Java object with a constructor that accepts all the required attribute values to create the value object. A value object is practically read-only after its creation, as there is no method to reset the values. Moreover, the Value Object Assembler pattern provides a compound object graph to enable chunky, rather than chatty, method calls to reduce the overheads in remote invocations. The fast lane reader pattern ought to be used for read-only data access, such as an online catalog. Read-only access to large quantities of tabular data should not use entity beans.

JDBC Statement Object

Similar to the PreparedStatement object discussed below, an application should cache and reuse other JDBC statement objects so that the complex statement objects do not need to be recreated from scratch over and over again.

Message-Driven Bean (MDB)

An MDB is an enterprise Javabean that enables an application to process messages asynchronously. A client does not call an MDB directly. Rather, the standard callback function, onMessage(), is invoked in the same way as a JMS message listener. In some sense, the incoming messages are "cached" in the queue to allow for maximum throughput.

O-R Mapper

Most Object-Relational (O-R) mapping solutions provide some caching services. For example, the Hibernate product (Hibernate, 2006) supports four different caching services with the cache data stored in memory, disk, or cluster: EHCache, OSCache, SwarmCache, and TreeCache.

PreparedStatement

The JDBC prepared statements are cached in many Java EE application servers. Instantiating PreparedStatement objects is a time-consuming operation, and transactional Java EE applications usually execute the same structuresd query language (SQL) statements with different parameters repetitively. Make sure that an application takes advantage of prepared statements whenever possible.

Data and Enterprise Resource Layer

ADO.NET

In the recent ADO.NET version, a new signaling feature called Query Notifications is added for the sake of refreshing the cache of read-mostly lookup tables.

Data Grid

A data grid deals with the controlled sharing and management of large amounts of distributed data. The data grid products from leading vendors provide highly scalable, self-managed distributed data caching solutions for distributed applications in Java and .Net, enabling enterprises to predictably scale large-volume systems.

Enterprise Service Bus (ESB)

ESB is an architecture style that exploits Web services, messaging middleware, intelligent routing, and transformation, as a ubiquitous integration backbone through which services, systems, and applications interact with each other. Caching is extensively used in many ESB implementations, such as service locators.

Page-Centric Model 1

As compared to the MVC Model 2, the Model 1 architecture is page-centric, primarily for simple Web applications. In Model 1, the JSP pages access the backend data source directly in a pull mode. Appropriate data access and caching as well as view helpers should be designed. Chunky interfaces serve better than chatty interfaces in Model 1.

Prefetch

Prefetch is a technique to proactively retrieve the required data elements from the data stores by predicting what a user will most likely need in the subsequent interactions with an application. Combining this means with other asynchronous technologies like AJAX can significantly accelerate the overall application performance.

Result Set Cache

A result set from a query to the backend database management system (DBMS) server ought to be cached to avoid unnecessary subsequent hits to the database system. The cached data content may be converted to a different data structure from the original result set, such as value objects or transfer object assemblers.

Stand-In

In case the backend systems go down for some reason, services to the front-end applications can be made uninterrupted by using a stand-in, which is a temporary data store to cache the data from the backend data sources. This is particularly useful for read-only data, though noncritical data can also be served to minimize the impact of the downtime in the backend systems.

Stored Procedure

For a complicated set of database operations, stored procedures may be a viable option to make use of the optimized processing in DBMS to produce the result sets more effectively. On the other hand, the business logic is split over two layers, the application layer and data persistence layer, which deems a bad practice from the maintainability and design standpoints.

Cross-Layer

Caching Utility Component

There are many innovative caching utility components available for data caching (Shan, 2004). OSCache (OpenSymphony, 2005) is a tag library that supports cache in the scope of session and application. It caches postprocessed JSP fragments in the Web tier, with the duration specified as an attribute in the cache tag. The OSCache tag library implements a properties file installed in the /WEB-INF/classes directory, which allows a developer to set attributes for operational preferences. The *cache.path* property points to the location where the cache files are placed. The *cache.debug* property specifies if the debugging messages will be produced, and the *cache.unlimited* property may be set to ensure that the cache disk space is unlimited.

Another interface is the CacheFilter, which is a Servlet 2.3 filter that caches entire responses with both text and binary content. OSCache can be configured to use either memory persistence or disk caching. The latter writes the cache entries to the hard drive to survive a server crash and restart.

Design Patterns

Flyweight and Façade are two powerful design patterns in caching implementations. For example, accessing entity beans from a Servlet can be very inefficient and difficult to maintain. Session Façade pattern is an effective method to encapsulate entity bean access in a session bean that accesses the entity bean through a local interface to avoid excessive remote calls. Other well-known design patterns (Broemmer, 2002) may be leveraged in the cache design, such as proxy, lazy instantiation, and so forth.

Disk I/O

An application must minimize the file reads/writes from the hard drive. For instance, the application metadata, typically stored in a configuration file, should be read once at startup and cached in the application as a singleton. Audit and logging data may be buffered and written to the disk asynchronously to minimize the I/O hits. Other template files are usually cached in the processor, such as XSL stylesheets.

DNS

The DNS entries may be cached to minimize the lookup calls to the DNS servers. A machine may also take advantage of the local *hosts* file, which maps IP addresses to domain names. Moreover, the IPs of the most frequently used partner servers can be cached in the application memory after the first-time lookup in the local *hosts* file or the DNS server.

In-memory Database System

In-memory database systems (IMDS) have emerged specifically to meet the performance needs and resource availability. IMDS resides entirely in memory. Almost every traditional DBMS solution incorporates caching to keep the most recently used portions of the database in memory, owing to the performance drain caused by physical disk access. Caching logic includes cache synchronization, which ensures that an image of a database page in cache is consistent with the physical database page on disk. In contrast, IMDS eliminates caching so that a significant source of complexity and performance overheads are slimmed down, and in the process, the memory and central processing unit (CPU) requirements of the IMDS are reduced.

Object Caching

Object caching is useful to complex objects that take a comparatively long time to instantiate. In a Java EE application, this includes objects like the JNDI resources such as EJB home interfaces, data sources, JMS connection factories, and LDAP. Caching can be applied to complex components or objects at the application level that make use of other external resources that involve disk input/output (I/O), networking, marshalling/unmarshalling, or other moderately expensive operations. In object caching, all objects must be made thread-safe to handle simultaneous access by multiple callers. For example, the ThreadLocal class ought to be used for the local variables belonging to individual threads only. Another efficient way of object caching is object cloning.

Object Pooling

Reusable objects of the same type can be recycled via an object pool to eliminate unnecessary instantiation and garbage collection. It involves some special handling to deal with the pool management. Though the code complexity grows in this approach, the performance can be improved, and better control over certain resources can be gained. A thread pool, as an example, provides reusable threads that can be utilized interchangeably in an application.

Object Type

While the primitive data types in Java reside in the memory stack, each object instance created in an execution process takes up some memory space on the heap. And the garbage collector is obligated to periodically handle every object instantiated, either to determine whether the object is still referenced by an active process or to release it. The primitive data types are preferred over class types in programming. A common example of this occurs when String objects are used carelessly. Unlike in C, Strings in Java are objects, which consequently brings overheads. Even simple operations like text processing can become slow if String objects are used too much. A solution to this is to utilize the StringBuffer class, resulting in fewer objects in the logic.

Precompiling

A precompiling concept is introduced for caching purpose. All static data stored in a dynamic fashion, say in a configuration file, are plugged in at the place where the data are used, when the deployable build is constructed. This is similar to the inline function in C++ applications. Alternatively, the dynamic data elements may be externalized in a file that is updated and cached at deployment time and runtime, while keeping the keys that are static in a configuration or properties file for the application to look up.

SOAP Processing

Simple Object Access Protocol (SOAP) is an extreme markup language (XML)-based object invocation protocol. SOAP is descriptive but larger due to the volume of tags. SOAP marshalling and unmarshalling incur moderate overheads, which may impact the application performance. XML-binary Optimized Packaging (XOP) provides a more efficient serialization of XML by means of MIME encoding. Message Transmission Optimization Mechanism (MTOM) uses XOP to encode portions of SOAP messages, while still presenting an XML Infoset to the SOAP application. Another alternative is XFire (2006), which is an open source standards-compliant SOAP framework.

Web Services

The emerging Web services specifications, WS-Resource Framework (WSRF) and WS-Addressing, are becoming the de facto methods to enable stateful Web services in which the state information is cached during the life cycle of a session.

XML Processing

As XML is broadly used in distributed applications, XML parsing and construction become commonplace. However, XML processing is a computing-intensive operation. The event-based SAX is preferred to the tree-based DOM, whereas the Streaming API for XML (StAX) is a bidirectional API via pull parsing.

FUTURE TRENDS

As new technologies and methods emerge at an unprecedented pace, the application development is migrating from the traditional object-oriented approach to a component-based model and further to a service-oriented paradigm. Different techniques and approaches are expected to converge, and therefore engineering patterns will be consolidated and standardized. Future work addresses how to effectively combine appropriate caching patterns in related layers and treat the caching design as a holistic aspect in the overall application technology stack. Collaborative global optimization of caching among dependent applications and infrastructure is also of interest to achieve the best response time and throughput for a set of Web-based partner systems. Dedicated caching servers or appliances are promising to provide the distributed caching capability as a common service. Data caching services tend to integrate seamlessly with other relevant technologies to form a fabric environment, such as grid services, enterprise services bus, virtualization, metadata, cloud computing, enterprise information integration, and content management services.

CONCLUSION

Data caching is a crucial design element in distributed system development. Data caching not only improves the application performance and availability, but also provides the application-level scalability in addition to the vertical and horizontal scaling at the hardware level. The justification of the requirements and benefits of data caching is presented. A variety of effective data caching techniques are evaluated in this article to cope with the complexity of the caching design solution in an n-tier architecture. The caching implementations are classified to the client, Web, application, integration, and database/enterprise resource layers. A broad range of data caching patterns are analyzed: network appliance, HTML hidden field/frame, Http header, URL rewriting, cookie, HttpSession, stateful session bean, entity bean, Servlet context singleton, ServletRequest attribute, .NET API classes, application frameworks, DNS caching, design patterns, object caching, object pooling, disk I/O, data grid, in-memory database systems, as well as open-source distributed cache utilities. Other important considerations and limitations are articulated in the context. Future trends are also discussed.

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KEY TERMS

AJAX: Asynchronous JavaScript and XML.

Connection Pool: A cache store of connections maintained in the memory so that the connections in the store can be reused.

Data Cache: A data block that contains frequently accessed data in a textual or binary format, which may be either saved to a persistent storage at the client or server side, or persistent in the memory for the lifetime of a single client request, a user session, or an application process.

Design Patterns: Common solutions to common problems, particularly in software design.

Edge Side Includes: A markup language that enables partial page caching for HTML fragments.

Http Cookie: A message given to a Web browser by a Web server, and the text string is sent back to the server each time the browser accesses a page from the server.

O-R Mapping: A technology that integrates object-oriented programming language capabilities with relational databases.

Proxy Server: A software or hardware device that enables applications to connect to other network resources in an indirect fashion.

Web Application: A server-based application that is accessed with a Web browser over a network.

Web Application Framework: A reusable, skeletal, semicomplete modular platform that can be specialized to produce custom Web applications, which commonly serve the Web browsers via the Http(s) protocol.

Data Flow Diagram Use to Plan Empirical Research Projects

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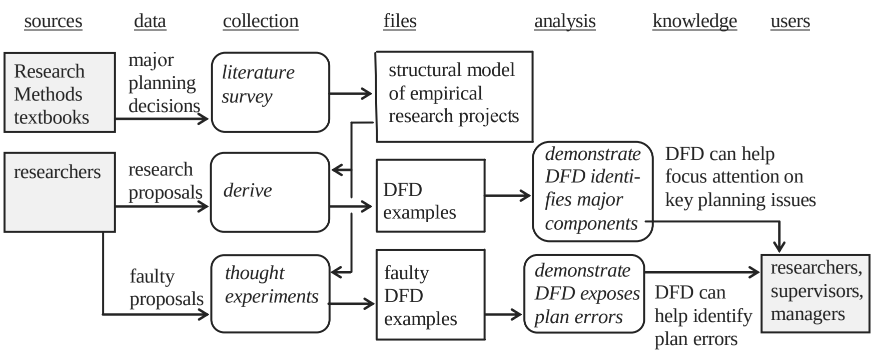
INTRODUCTION

Yourdon and Constantine (1979), De Marco (1979), and Gane and Sarson (1979) introduced the data flow diagram (DFD) more than a quarter of a century ago, as a systems planning tool that is particularly useful in the fields of software engineering and information systems development. But the DFD is not restricted to those fields. Empirical research projects are systems too (which consist of interconnected sources, data, collection processes, files, analysis processes, knowledge, and users), and those systems are similar to information systems. This article reports how the DFD can also be useful in planning empirical research projects. This finding should be advantageous to research planners, individual researchers, research advisors, research supervisors, or research managers. And it should be especially advantageous to research planners in information and communication technology (ICT) because they know DFDs already, so they can get the planning advantages with little or no extra learning effort. This finding was obtained from two research projects. The first was planned without the aid of a DFD and failed. It was then replanned with a DFD and redone in a second project, which succeeded. The DFD that turned failure into success is Figure 1.

The second project had the exploratory aim of demonstrating that DFDs *can* be useful in planning empirical research projects (the more ambitious aim *should* calls for further research). Figure 1 shows that the aim was achieved by means of DFD examples that speak for themselves: so no elaborate data collection was necessary and neither was any sophisticated data analysis. First, textbooks of research methods were surveyed to develop a structural model of empirical research projects: that model identifies seven major types of components as key planning issues. Then DFDs were drawn from the research proposals of three recent research projects to demonstrate that those DFDs explicitly identify the major decision components. This means that DFDs can be useful in focusing attention on the key planning issues. Third, faulty DFDs were drawn, some from initial proposals of old research projects, and others by conducting thought experiments that distorted the structural model in various ways (Brown, 1992): these examples demonstrate that DFDs readily expose planning errors. This means that DFDs can be useful in identifying planning errors. Therefore, by focusing

Figure 1. DFD of research on DFD's in research



researchers' attention on key planning issues and by enabling them to identify planning errors, DFDs can be useful in planning empirical research projects.

BACKGROUND

DFDs were introduced in 1979 by Yourdon and Constantine, De Marco, and Gane and Sarson, and thereafter were recommended by many other authors (e.g., Awad, 1985; Budgen, 1994; Burch, 1992; Buxton & McDermid, 1991; Coleman & Baker, 1997; Conger, 1994; Fairley, 1985; Hawryszkiewycz, 1991; Jeffrey & Lawrence, 1984; Kendall & Kendall, 2002; McDermid, 1990; Millet, 1999; Powers, Cheney, & Crow, 1990; Satzinger, Jackson, & Burd, 2004; Schach, 1993; Sommerville, 1992; Stevens, 1981; Weinberg, 1980; Whitten & Bentley, 1998; Wieringa, 1998). DFDs have mostly been used to plan software packages and information systems by outlining their major components in a top-level DFD, and then decomposing major processes into more detailed lower-level DFDs. But only top DFDs are considered here. Yourdon and Constantine noted that the major processes in the top DFDs are usually afferent or efferent (this important insight has largely been ignored by current textbooks). In the case of an information system, afferent means data collection, and efferent means information extraction: so the top DFD of an information system can be drawn as a series of rows shaped like Figure 2 (Mende, 2007).

Therefore, Figure 2 serves as a structural model of an information system.

An empirical research project normally has a similar structure. This emerges from textbooks on research method (e.g., Babbie, 1989; Bailey, 1987; Breakwell, Hammond, & Fife-Shaw, 1995; Heiman, 1995; Huysamen, 1994; Kerlinger, 1986; Leedy, 1989; Mason & Bramble, 1978; McMillan & Schumacher, 1997; Mouton, 2001; Neuman, 1994; Robson, 1993; Singleton, Straits, & Straits, 1993; Terre, Blanche, & Durrheim, 1999; Welman & Kruger, 2001; Williamson, Karp, Dalphin, & Gray, 1982; Zikmund, 2003). These textbooks mention seven major components of a research project:

- The people who require knowledge of a particular phenomenon (knowledge users);
- The specific items of knowledge they need in order to cope with that phenomenon;
- The analysis processes that derive the needed knowledge from file data;
- The files that store data for analysis;
- The collection processes that get data into the files;
- The data to be collected, and
- The sources of the data.

Thus, an empirical research project normally has the structure of Figure 3.

Figure 4 compares Figures 2 and 3.

It shows that information systems and research projects are similar in two ways. First, they are similar in the interconnections of the components; second, they are similar in the functions of corresponding components.

The general system theory of von Bertalanffy (1972) predicts that when two academic fields are concerned with systems that are similar in structure or function, that is, homologous, then some of the knowledge in the one field can be transferred to the other. That prediction was confirmed earlier by cases of homological knowledge transfer between the field of information systems and several related fields (Mende, 1990). Now the prediction is confirmed further, by a case of homological knowledge transfer between the field of information systems and research method.

Figure 4 shows that information systems and research projects are homologous. So (although the two systems differ in other dimensions, e.g., run frequency), general system theory suggests that the homologies should allow some principles of information systems to be transferred to the field of research method. Subsequent sections confirm that indeed one principle can be transferred, namely the DFD.

Figure 2. Structural model of an information system

Figure 3. Structural model of an empirical research project

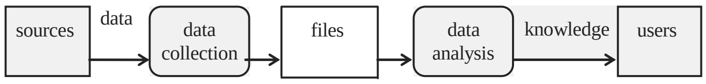
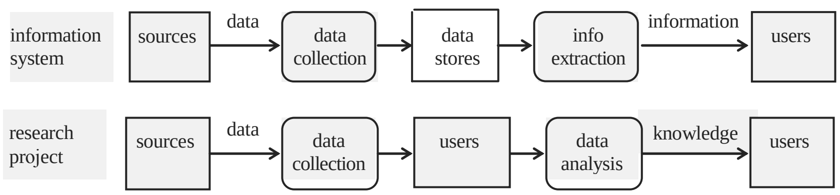


Figure 4. Similarities between a research project and an information system



SEVEN RESEARCH PLANNING ISSUES

An empirical research project normally consists of three stages: planning, execution, and write-up. The planning stage is addressed by all the above-mentioned textbooks of research method. They mention seven key planning issues: the interconnected project components in Figure 3 (sources, data, collection, files, analysis, knowledge, and users). Research planning calls for decisions on all seven issues, decisions that ought to select the best components and the best interconnections.

Planning is usually the most difficult stage of an empirical research project. Thus, key planning decisions may be ignored, or the corresponding planning decisions may be sub-optimal, or even wrong. Then some project components may be weak or even infeasible. If even one component is infeasible, the entire project is at risk of failure. For instance, the project is likely to fail if sources are unwilling or unable to provide appropriate data; if a collection process cannot get data from the sources; if the files store insufficient data for analysis; if an analysis processes cannot produce the intended knowledge; or if no one can use the resulting knowledge for any significant purposes. Alternatively, if a component is sub-optimal, overall project success is impaired. For instance, the project is likely to be ineffective if it produces knowledge that few users need, instead of knowledge that many users need. And it is likely to be inefficient if it collects data from reluctant sources instead of willing sources. To avoid such errors, research planners need a tool that:

a. Facilitates strategic thinking by focusing attention on the key planning issues
b. Facilitates error detection by exposing errors of incomplete planning or wrong planning

None of the research method textbooks reviewed by the author mention any tools that are useful for either of these purposes, but the next three sections demonstrate that a DFD can be useful for both purposes.

DFD FOCUSES ATTENTION ON KEY PLANNING ISSUES

The seven column headings (sources, data, collection, files, analysis, knowledge, and users) serve as a template which invites researchers to address the key planning issues by entering major components into each column, and connecting them appropriately. Researchers have actually used this template to draw DFDs of three research projects. The first DFD is Figure 1 (of the second research project behind this article). The second is the DFD of a research project on business process reengineering, which was successfully completed by one of the author's students (Figure 5).

This project produced two items of knowledge, namely confirmation of the hypothesis that the "information systems triangle" serves to classify the causes of business process reengineering (BPR) failure and an answer to the question of the relative importance of the triangle categories. The hypothesis was confirmed

Figure 5. DFD of a project on business process reengineering

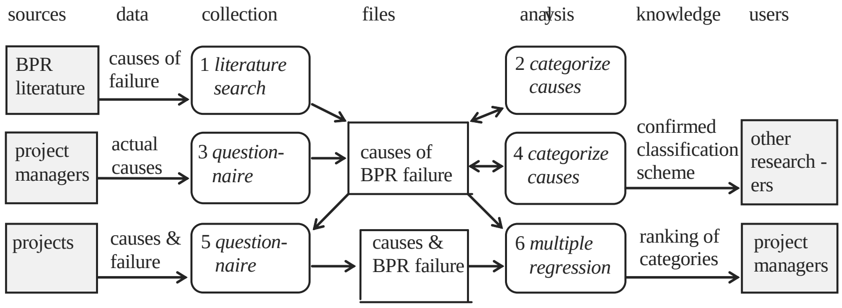
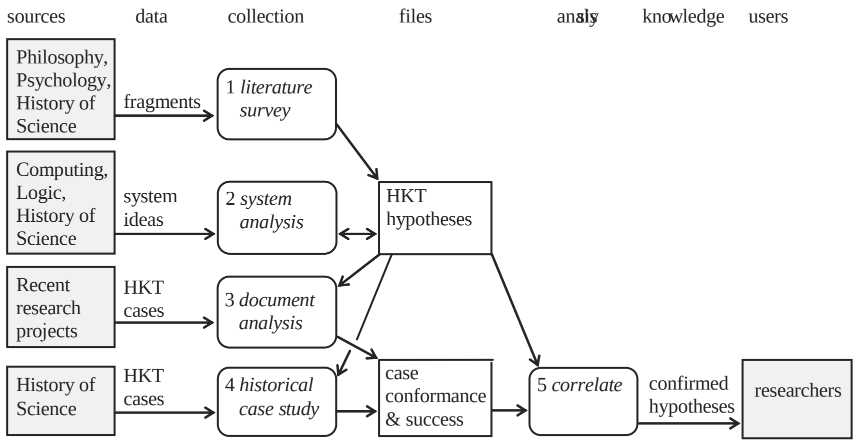


Figure 6. DFD of a project on homological knowledge transfer



in four research steps: (1) identify causes of BPR failure found by previous researchers; (2) allocate those causes to the triangle categories; (3) let practitioners identify unimportant listed causes and important unlisted causes; (4) eliminate unimportant causes from the categories and add important ones. The question of relative importance was answered in another two research steps: (5) get a sample of projects and let their managers assess the degree of project failure and the extent to which the causes were present in each project and (6) correlate degree of failure with the presence of causes; eliminate insignificant causes; regress failure against the causal categories; and rank the categories in sequence of their regression coefficients. The third example is the DFD of a research project on the research uses of homological knowledge transfer (HKT). The project plan has been approved by a faculty research committee, and the project is being carried out by the author. The DFD is Figure 6.

This project aims to answer four questions: what kinds of principles can be transferred between academic disciplines that study homologous systems?; when and why should those principles be transferred?, and how should researchers proceed to transfer them? The questions are being answered in five research steps: (1) integrate previous researchers' ideas to get hypotheses; (2) refine those hypotheses by analyzing HKT as an information system; (3) collect case evidence of living researchers' HKT projects, assess the extent to which each case conforms to the hypotheses, and rate their success; (4) collect further evidence from cases of HKT mentioned in the history of science; (5) confirm the

Table 1. Planning questions

Users:	Who needs knowledge of the phenomenon under investigation?
Knowledge:	What knowledge is most useful to cope with the phenomenon?
Analysis:	What analysis methods are best for producing that knowledge?
Files:	What file data are most appropriate for analysis?
Collection:	What data collection methods are best for getting the file data?
Data:	What data are available for collection?
Sources:	Who are the best sources of the data?

Figure 7. Sources and users are omitted: Data may be unavailable and knowledge unusable

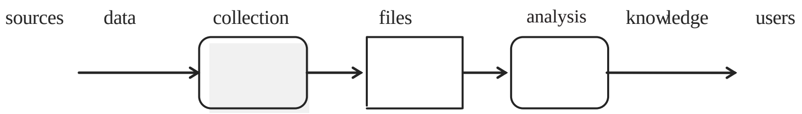


Figure 8. Knowledge and users are omitted: No useful knowledge may be produced

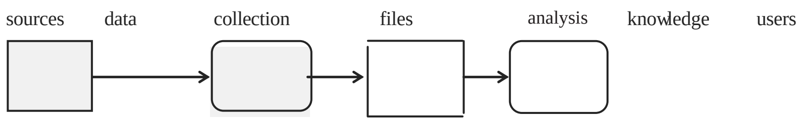


Figure 9. Source and data are omitted: Data collection may be infeasible

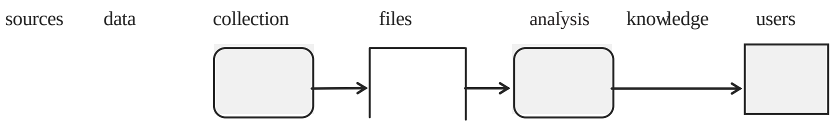


Figure 10. The second analysis process is omitted: The second knowledge may be impossible to produce

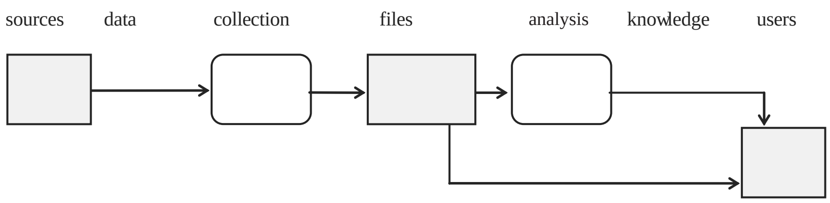
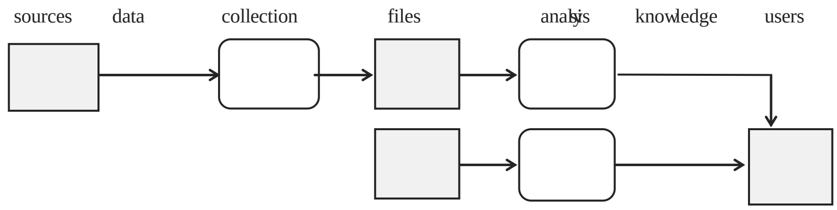


Figure 11. The second data source and collect process are omitted: The file may be impossible to obtain



hypotheses by correlating success with conformance to hypothesis. In order to draw the three DFDs, the researchers had to consider each of the major planning components and their interconnections by asking and answering questions such as the seven in Table 1.

So, the DFDs focused the researchers' attention on the key planning issues. Therefore, by Mill's law of agreement, DFDs can focus researchers' attention on the key planning issues. The next two sections show that DFDs can also be useful in helping researchers identify major planning errors. Several examples demonstrate that a DFD readily exposes a wide variety of planning errors: some resulting from incomplete planning and others from wrong planning.

DFD EXPOSES ERRORS OF INCOMPLETE PLANNING

A research plan is incomplete if any of the key planning issues has not been addressed, leaving one or more of the major decision components undecided. Such errors of omission are not uncommon. (In fact, it was the astonishing frequency of those errors in students research plans that motivated the author to apply DFDs to research planning.) A DFD readily exposes many errors of omission in the form of gaps in the columns (the names of the components do not even have to be read). Figures 7 to 14 give examples.

A DFD also exposes further errors of incomplete planning that can be detected by checking for vaguely named components. Figure 12 (with its six cases a–f) gives some examples from a project to confirm the hypothesis that ICT use is correlated with user age (the symbol $\propto$ stands for "is correlated with").

All those planning errors are difficult to detect in a 10-page research plan (e.g., a research proposal), where core ideas cannot easily be identified because they are obscured by a multitude of peripheral ideas. But they are easy to detect in a DFD, which contains core ideas only, and their explicit connections. Therefore, by Mill's law of agreement, DFDs can help research planners to detect errors of incomplete planning.

DFD EXPOSES ERRORS OF WRONG PLANNING

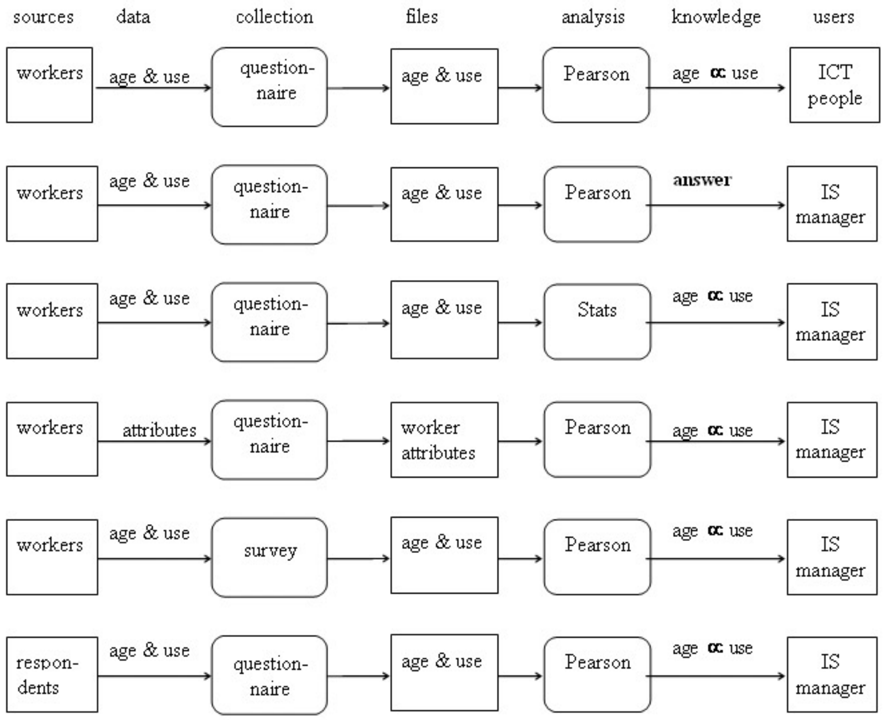
Even if all incompleteness errors have been eliminated from a research plan, it may still have errors of sub-optimality or infeasibility, mainly involving wrong connections. A DFD readily exposes many such errors, which can easily be detected by comparing adjacent components. Figure 13 (with its four cases a–d) gives some examples.

All the above planning errors are difficult to detect in a 10-page research plan, where core ideas cannot easily be compared because they are obscured by a multitude of peripheral ideas. But they are easy to detect in a DFD. Therefore, by Mill's law of Agreement, DFD's can help research planners to detect errors of wrong planning.

CONCLUSION

DFDs can focus researchers' attention on the key planning issues, and they can also help research planners detect errors of incomplete and wrong planning. Therefore, DFDs can be useful in research planning. They are especially useful to ICT people, who already know how to draw and interpret DFDs. Therefore, if ICT people have to plan empirical research projects, they should consider using data flow diagrams.

Figure 12. (a) Vague users: no one may actually need the knowledge, (b) vague knowledge: the answer may be useless, (c) vague analysis: the statistical method may be weak, (d) unspecified files and data: attributes may not include age *and* use*, (e) unspecified collection: may be infeasible, (f) unspecified source: may not exist*



FURTHER RESEARCH

1. Further research may show that DFDs *should* be used in planning empirical research projects. For instance, a group of research supervisors might collect plan documents of badly planned research projects, draw DFDs to detect planning errors, and apply the binomial test to prove that DFDs expose a majority of those errors.
2. According to the maxim "forewarned is fore-armed," research planners need a list of common research planning errors (especially errors that can be detected using a DFD). And following Murphy's law "if it can go wrong then it will go wrong," that list should be comprehensive.
3. In the planning stage of an empirical research project, a DFD can be used in two ways. One way is to use the DFD as an evolving project outline *throughout* the planning stage. Research planners could try to draw a tentative DFD early in the planning stage and then aim subsequent planning efforts at improving the initial DFD. The other way is merely to use a DFD as a final check on the plan. Research planners can defer drawing the DFD to the end of the planning stage and then use it to check for errors in the major decision components and their interconnections.
4. As research planning involves decision making, the Simon model of decision making may well be applicable. Research planners might generate several alternative DFDs, then evaluate each DFD and select the best one.
5. In a very complex empirical research project, planning might be facilitated by decomposing some of the process components into more detailed DFDs.
6. In planning a complex information system, a DFD is often used together with an entity relationship

Figure 13. (a) The file has data on age and use, but no age data are collected, (b) the analysis correlates age with use, but the file has no data on age, (c) Delphi is inappropriate for getting data on age, (d) the t-test is a weak way of establishing a correlation

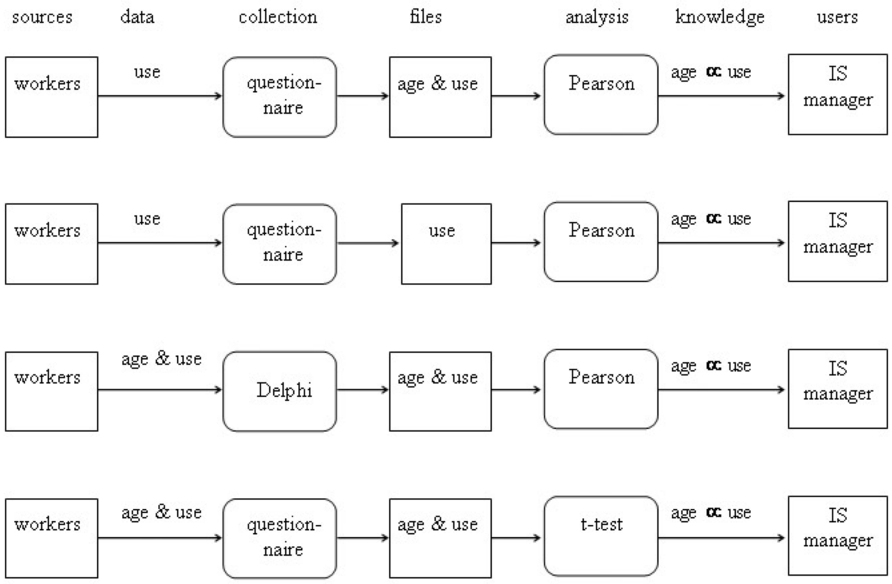


diagram to optimize files. Perhaps an ERD could also be used to optimise the files of a complex research project.

7. As empirical research projects and information systems are homologous, perhaps not only the DFD can be used in research projects, but also other IS development aids, such as CASE tools and object-oriented tools.
8. In order to turn any academic field of study into a science, there is a need for theoretical research as well as empirical research (Mende, 2005). The DFD might be useful in planning theoretical research projects too.

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KEY TERMS

Data Analysis Process: A combination of human activities and computer processes that answer a research question or confirm a research hypotheses. It answers the question from data files, using empirical methods such as correlation, t-test, content analysis, or Mill's method of agreement.

Data Collection Process: A combination of human activities and computer processes that get data from sources into files. It gets the file data using empirical methods such as questionnaire, interview, observation, or experiment.

Data Flow Diagram: A diagram of the data flow from sources through processes and files to users. A source or user is represented by a square; a data file is represented by rectangles with missing righthand edges; a process is represented by a circle or rounded rectangle; and a data flow is represented by an arrow.

Data Source: An entity or group of entities from which data can be collected. The entities may be people, objects, or processes.

Empirical Research Project: The entities and processes that answer a group of related research questions or confirm a group of related research hypotheses using empirical methods of data collection and data analysis.

Knowledge: Information about a class of entities, events, or relationships, which is likely to remain true for a relatively long period of time.

Research Hypothesis: A tentative answer to a research question. A previous researcher may have suggested a potential answer that could be verified empirically, or the researcher may be able to deduce consequences of a previous researcher's model or theory.

Research Problem: A phenomenon that people cope with by applying knowledge. It usually divides into several subproblems, for example, a classification of the different kinds of entities and events involved; cause-effect relationships between attributes of entities and events; and techniques for manipulating relationships to achieve desired outcomes.

Research Question: An unsolved subproblem of a research problem, for example, a classification scheme that is needed but not yet available, a classification scheme that is not entirely comprehensive, an unknown cause-effect relationship, or an unknown technique.

From Distance Education to E-Learning as Integrated Training

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INTRODUCTION

In the last few years, the methods for the delivery of professional and educational training have radically changed. More knowledge and information are required from people in order to achieve an active role in their social and professional life. At the same time, the period of validity of new information and the currency of competencies quickly decrease. As a consequence, *continuing education* is perceived as necessary, even if the traditional methods of delivery are sometimes limited by the distance between the learner and the training centers. For this reason many continuing education programs make use of distance learning techniques that make the adoption of *distance education* programs more popular.

THE EVOLUTION OF DISTANCE EDUCATION

The distinction of distance education into three *generations*, originally made by Garrison (1985) and Nipper (1989), is widely accepted.

The *first generation* began in the 19th century in the United States and Canada. It utilized postal correspondence to provide basic and vocational education to students, mainly adults, across the country, and was especially popular in remote areas. Thus, distance education was based on the use of regular mail to send books, duplicated notes and tests to students who then sent the tests back to be corrected.

Between 1950 and 1960, thanks to the birth of television, the so-called *second generation* systems were added to the traditional ones. Originally, they consisted of lessons recorded on video and audiotapes and later consisted of teaching software packages, CD-ROMs, other media storage formats, and e-mail.

In this period the first distance education universities were founded. The most widespread and well known is the British *Open University* established in 1969. It represents one of the most interesting model for adult training. It began by providing its training offers through both radio and television, supported by paper materials and by video and audiotapes. Later, it created study centers, the tutors-advisors networks, and self-learning groups. Today it represents the biggest university in the UK and this model has spread all over the world. Among the "open" universities there are the Spanish *Universitat Oberta de Catalunya* and the U.S. *City University* and *United States Open University*, which has gained a leading role in part-time education and in adult in-service training.

Today's distance education, known as the *third generation*, is called *e-learning* (electronic learning) and makes use of network connections, by exploiting all the ICT (*information & communication technology*) resources. Garrison underlines the improvement in the relationship between teachers and students while Nipper emphasizes the revival of cooperative learning that has characterized adult education. According to Nipper, the implementation of network technologies alone is not enough to characterize distance learning as belonging to the third generation. It may be classified as the second generation if technology is considered as a means through which material is distributed to students.

The real difference between the generations is in how learning has been perceived historically. In the first two generations learning is not seen as a social process and consequently it does not imply dynamic interactions either between teachers and students or among students. Since there is no interactivity, learning becomes an individual rather than a social process. The third generation goes beyond this "social divide" and learning becomes a true social process. This is possible thanks to new forms of sharing and of interpersonal dialogue not only in the relationship between the teacher and the student but also between the students themselves. Networked communication encourages "one-to-one", "one-to-many" as well as "many-to-many" exchanges of information. This allows a student to interact and work cooperatively with groups of students. Virtual classrooms can be set up. In this case, relational and cooperative dynamics can be quite complex, sometimes similar to those that develop in real classroom settings. As emphasized by the leading experts in this field, the main features of third generation environments are the sense of being part of an ongoing community and the ability to set up an emotional environment of rich interpersonal and collaborative relationships. In this case, the difference when compared with the second generation systems is clear as they were identified by the perception of learning as an isolated process.

The *fourth generation* is characterized by virtual learning environments or e-learning platforms which are complex systems, designed to facilitate e-learning. These e-learning systems are divided into two main groups: (1) ILS (integrated learning system), also called LMS (learning management system), that imports, assembles and instructs courses and administers tests, by tracking all the operations made by students; (2) LCMS (learning content management system) based on the creation, recording, organization and reuse of contents, set in *learning objects* or teaching units that form a complete topic.

In brief, it can be stated that the LMS is based on the instruction of the courseware and of the training process while the LCMS is based on the creation of contents that can be supplied independently from the type of LMS that is available.

E-LEARNING FEATURES

One of e-learning's fundamental characteristics is the possibility for students to access the contents and materials anytime and anywhere. In order to attend an online training course, it is necessary to have only a computer connected to the Internet. Students who live in isolated and remote places may attend a course avoiding the possibility of being excluded by training offers available to the luckiest ones.

Another important advantage of e-learning is *flexibility* in the personalization of the training process according to the students' learning styles, competencies and the specific objectives each is to achieve. Through the use of particular software, instructors have the opportunity to monitor the results of the students' work, the level achieved by each and the possibility to update their online documents (notes, images, videos, etc.).

The most widespread instruments that assure interactivity and as a result the motivation to learn are:

- *Online forums*: A place where students exchange information on specific topics. The forum moderator must ensure that the exchange of viewpoints and beliefs do not go beyond the discussion objectives and topics.
- *Chat rooms and mailing lists*: They represent socialization moments. The chat room and mailing list administrators should provide detailed information about their next meetings and should act like a filter for the informal requests of feedback during the communication process. Chat rooms and mailing lists connect the virtual community members with common interests and individuals charged with working on projects in a group setting.
- Requests for deeper *investigations* that develop in any situation, both formal and informal.

E-learning develops both synchronously (in real time) and asynchronously (in deferred time). In the former case, students may ask questions of the instructor during a videoconference in real time and through the Internet (*live session*) either by text (*chat*) or by audio (if the workstation is equipped with a microphone). In the second situation, communication is asynchronous when students communicate with instructors via e-mail, through discussion forums or when reading the course material available online according to their own needs and schedules. Thus, the key-concept is "*interaction*", which is perceived as the opportunity for students to influence the teaching process as well as to be influenced by it.

An e-tutor is fundamental in this process and has multiple roles. The *tutor-instructor* plans and distributes material online (also on Web pages) and interacts with the participants through various applications such as mailing lists, e-mail, newsgroups, videoconferences, and so forth. The *tutor-facilitator* organizes the materials to be published online, increases motivation among students and facilitates observation, support, monitoring, and integration. The e-tutor may also be an *animator* and *moderator* with the same functions of the *tutor-instructor* and of the *tutor-facilitator* in addition to activities such as interaction, moderation, creating incentives, icebreaking, and entertainment. Moreover, the e-tutor should be able to initiate *peer tutoring* among the students. In this way the e-tutor can stimulate the knowledge-building and management of cooperative sharing (Rowntree, 1995).

TOWARDS AN INTEGRATED TRAINING MODEL

The distribution of knowledge according to these forms causes the student to be an active protagonist within the student's own learning process. As a result of the *learning by doing* model, it is possible to support the acquisition of specific concepts as well as the development of general skills, such as: the ability to collect information, to develop personal and critical interpretation skills, to make a decision and assess the results, to learn to identify and modify individual interpretative models on the basis of stimuli in the surrounding environment.

Today, the combination of multiple approaches to learning is very widespread. This model is called *blended learning* which blends e-learning with other traditional resources in order to merge the flexibility of the new tools and the functionality of the traditional ones (the classroom setting and paper material) retaining the best aspects of each. The main objective of this model is to use different resources, such as: alternating face-to-face sessions (to increase motivation and to share what has been learned), individual moments (to evaluate and strengthen what has been learned according to the needs of the individual), peer interaction and tutoring.

As has already been stated, new information and communication technologies go beyond the traditional limits set by the communication mediated by the computer thanks to the ability of setting up virtual communities ready to establish collaborative learning forms. Thus, the techniques involved in e-learning achieve educational goals, too. While pursuing their common interest, the members of a community are involved in several activities and discussions, helping each other, sharing information and building up relationships that allow them to learn together.

The educational and training value of virtual communities is underlined by the numerous learning opportunities offered by online interactions such as:

- Encouraging the comprehension of the materials to be learned through the integration of diverse viewpoints, information and ideas on the same topic (Clark & Slotta, 2000; Hoadley & Linn, 2000; Linn, Davis & Bell, 2004);
- Favoring the development of metacognitive abilities through cooperative activities (Park, 1999);
- Encouraging students to use new *problem solving* strategies as a result of their collaboration and dealing with authentic tasks (Herrington, Oliver, & Reeves, 2003);
- Encouraging social competences useful in teamwork (Edelson, 2001).

Even at the stage concerning the formation of the identity, the role carried out by the mediation instruments used during the interaction phase is fundamental: from language, considered as a mediation instrument par excellence, to the telematics environment resources. In particular, the last generation environments (text chats, discussion forums, Web pages, etc.) offer specific options that seem to support the dialogue nature and the social and cultural negotiation of identities.

On the basis of these reflections, it is necessary to encourage e-learning as a model of "integrated learning" where different forms, and numerous training and educational instruments can be used with the goal of making the most of their potential. Thus, this new educational training model is not only characterized by the integration of classroom teaching and online activities (*blended learning*) but also by the following elements:

- **Traditional face-to-face sessions:** Especially in the case of long and difficult courses of study such as undergraduate and postgraduate courses as well as university masters. Meetings at the beginning and at the end of the course can stimulate the construction of the virtual community and of the perception of the social meaning involved in the training process. Workshops and classroom sessions can be useful to reinforce mechanisms developed during collaborative learning sessions in the virtual environment.
- **Use of the Internet as a transfer and collaborative tool:** It is fundamental to consider the Internet as a medium through which it is possible to access study material, essays, and articles that concern the main course topic. It is not possible to consider e-learning without accounting for the use of the Internet as a collaborative means through which it is possible to set up virtual communities. For this reason, it is possible to make use of forums, chat rooms, discussion groups, and audio and videoconferences. Another way of integrating resources is to publish the results of group projects so that they can be downloaded.
- **Use of individual and collaborative learning models:** It is necessary that these two models are properly integrated. As with traditional training, in e-learning there are both individual and collaborative learning moments. Obviously there is a connection with the two different uses of the Internet. Each individual moment utilizes the Internet as a transfer means for the downloading of material from the net. Of course, the collaborative moment corresponds with the use of the Internet as a tool to facilitate group interaction. Ideally, the moment of individual growth is integrated with the moment of collective growth. As a result, the communicative revolution began thanks to the third generation distance education and allows the interaction with the e-tutor, the instructors and the students.
- **Use of synchronous and asynchronous models:** The potential of the Internet is well-exploited by distance education especially when educational training is delivered in both synchronous and asynchronous forms that are well integrated with the various applications of the Internet and the various forms of learning. If it is true that the structure of individual learning appears to be connected mainly to asynchronous interaction, the latter can also be used as a collaborative method. In particular, even if forums and discussion groups do not imply the live presence of the participants, they are nonetheless connected to the idea of training as a social process. These mechanisms are well exploited only through synchronous interaction in which a traditional classroom setting is created, where everyone can take part and be heard by everyone else in real time, asking questions to the instructor and addressing each other. The teaching activity and tutorship are facilitated by the spontaneity of synchronous interaction. The relationship between the instructor and the student is more real in a synchronous online context rather then in wide university classrooms where the instructor is not able to "reach" every individual.

CONCLUSION

E-learning as an integrated training model implies that all the possibilities offered by the third generation distance education are combined with the traditional training model. Synchronous interaction becomes fundamental in setting new mechanisms similar to those offered by the face-to-face model. As stated before, cooperative learning, typical in virtual communities, using certain techniques such as collaboration, cooperation, peer tutoring, and so forth, emphasizes the e-learning value both in training processes and in educational ones.

Everything considered, the possibility of realizing an interactive virtual environment is mainly due to the introduction of ICTs to the teaching/learning processes. In contrast, the face-to-face setting is still valuable thanks to the advantages offered by instant *feedback*. Distance education allows for widespread classrooms that provide qualitative, quantitative, and economical advantages.

Traditional educational training is a one-way process which follows a well-defined time frame and which models the contents on the basis of the users' results. Moreover, instructors follow a logical path and "force" the users to follow it. In the last generation of distance education, it is the student who constructs his/her own logical path: listening is on-demand and it is necessary to take advantage of multimedia tools. Organizing educational training courses by using a single learning format means to exploit all the advantages given by the integration of both formats.

Several e-learning processes have developed, based on a previously-existing distance learning format. However, if the course materials are simply an online version of those used in traditional training courses, an obstacle both to interaction and distance learning may be created because the situation is not taking advantage of the new method of learning.

It is necessary to reorganize the traditional learning models in order to create new ones that can exploit the new educational possibilities offered by the utilization of information and communication technologies.

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KEYWORDS

Asynchronous Learning: Learning process during which communication among participants occurs in deferred time.

Blended Learning: Teaching arrangement that combines components and methods of face-to-face settings with those of e-learning.

Computer-Based Training (CBT): Learning method in which the student learns by executing a software package on a computer. It refers to a self-instruction course where the student attends lessons on the computer, interacts with the software, answers questions and executes operations mainly through a CD-ROM or a floppy disk .

Courseware: Collection of teaching material in digital format delivered through software, multimedia and data transmission systems.

E-Learning: Computer-enhanced learning that offers the possibility of delivering training course contents electronically by the Internet or the Intranet networks. It is a very flexible solution because the user can personalize it and easily access it.

E-Learning Platform: A software system designed to create a virtual learning environment through which it is possible to deliver training courses, administer and monitor them and access a series of facilities and arrangements.

Interactivity: Dynamic communication process that allows modification of a message on the basis of the choices made by the users. The message is related to previous messages and to the relationship between them. In a self-instructing course, interactivity depends on the interaction frequency, on the number of available options in each interaction and on the meaning of the interactions with respect to the course goals.

Synchronous Learning: Learning process during which communication among participants occurs simultaneously.

Virtual Classroom: Learning environment where instructors and students are separated by time and space but can communicate through an e-learning platform or other management applications. In an online course, several virtual classes may occur that correspond to several collaborative groups or they can be subdivided into various groups.

Web-Based Training (WBT): Type of training delivered through the Internet offering the possibility of including training in real time through the web and with the assistance of e-tutors and instructors. It represents an evolution of the computer-based training (CBT).

Distance Learning Techniques in University Courses

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INTRODUCTION

Distance learning (DL) is not, and must not become, a surrogate for traditional learning with the teacher (Trentin, 1998). For this reason, alongside virtual classroom technologies such as chat and video-audio conferences and methods typical of synchronous DL which requires the simultaneous presence of lecturers, tutors and students online, it is important to implement asynchronous interaction tools for:

- Accessing content;
- Self-testing;
- Distance dialogue between students, tutors and teachers.

Asynchronous DL therefore offers an important innovative possibility for classroom teaching (whether it be real or virtual): automatic link between content and structure.

From this it is easy to deduce that DL is characterized by three types of activity:

1. Transmission of content prepared by the teacher (configured as content expert);
2. Test and self-test of learning through the use of online interactive tools;
3. Dialogue between students, tutors and teachers.

This complex structure which generates articulated processes designed to create environments favourable to teaching but above all to learning, also requires to be considered, and above all defined, in the light of the roles and professional figures involved (Frignani, 2003).

This particular analysis begins by defining two macroareas:

- The teaching methodology area, to which all of the figures called upon to plan and manage the teaching and learning process belong;
- The field of the analogue, digital and online teaching technologies to which all of the figures called upon to plan and manage the technological process sustaining the teaching and learning process belong;

The definition of the professional figures who will be later described and the processes with which they are associated are the fruit of the ten years' experience which CARID (University Centre for Research, Teaching Innovation and Distance Learning) in the University of Ferrara has gained in the design and management of degree courses with integrated and distance teaching techniques.

TEACHING METHODS AREA

The first figure belonging to this field is the *scientific coordinator* who is the course designer from the content point of view. Together with teaching and technology experts the coordinator prepares the course design and flow chart. This figure is also required to have knowledge of the teaching-technological state of the art as regards the specific learning proposal for which the coordinator is responsible: the scientific coordinator's job is to manage the general course project, together with the director of studies and teaching managers, assuming responsibility for the scientific activities of the content experts.

The role of *content expert* tends to be assumed by the teacher of a course taught using distance teaching methods, since aspects such as the actual teaching of the course itself and the direct contact with the students are delegated to teaching tutors or content tutors. As such, the aforementioned teacher is responsible vis-à-vis the scientific coordinator and the area coordinator for defining the specific cognitive areas of the reference subject. The eexpert must be able to perform the wide range of activities listed next:

- Prepare teaching materials and a cognitive map of the topics that he/she intends to cover. The teaching materials will be fruit of the collaboration with the content experts, communication technology experts and teaching experts. The materials that are required to prepare shall be tools that, when used in synergy, facilitate learning and may be used as a guide for exploring and understanding the cognitive areas and content transmission tools (Learning Objects).
- Prepare, in close collaboration with performance assessment experts, tests and self-tests deemed suitable both in form and aims.
- Interact with the system tutor in the handling of organisational problems and with the content tutor for the management of tools geared to stimulate dialogue and online learning in students;

In addition to the specific subject-related skills, the expert is also expected to be familiar with the e-learning platform used, both as regards constructive philosophy and teaching logic.

Another important figure with a predominantly methodological slant is the *teaching coordinator* who has the role of guiding the work of the teaching managers of each course held using integrated and distance teaching methods.

His/her main task to constantly monitor the efficiency and efficacy of the course planning by controlling teaching organisation and management processes and ensuring that they comply with the procedures linked to the teaching methodology applied. More specifically, to successfully perform this task, he/she must be able to gather and process the information required to be able to control the quality of the teaching procedures applied.

By exercising this control, the teaching coordinator contributes to managing and guiding the learning processes and elevating them to high quality levels, orienting his/her work towards the attainment of the total satisfaction of all those involved. The teaching coordinator is also required to guarantee the efficiency of the system of communication between all the various subjects involved not only in the teaching process but also in the technological and administrative processes.

The *teaching manager*, on the other hand, is required to cover different responsibilities and possess different skills. In addition to having organisational skills he/she is expected to develop, among other things, managerial skills linked to integrated and distance multimedia teaching methodology with special emphasis on collaborative and online learning. His/her job involves planning the course syllabus and following it up, step by step, with a view to ensuring that it is taught efficiently and efficaciously. This figure is the main reference point for the tutors.

The main responsibility of the *tutor,* a figure that will be described in the present paper according to the various characteristics required, is to artificially reconstruct the interaction processes with the student so as to eliminate the condition of physical detachment created by the distance teaching method.

The support offered by the tutor has a dual and circular nature: on the one hand, it aims at overcoming cognitive difficulties, and on the other, by combating students' sense of inadequacy in the face of learning tasks, it assumes a degree of emotional involvement which stimulates the student's motivation.

The tutor, therefore, has the responsibility to help the students contacting them by telephone, via fax, by meeting them directly and, first and foremost, via the internet (e-mail and forums) in order to provide information with regard to the activities to be carried out and to assist them in their learning experience. On the basis of the main activity performed, two different specialisations may be distinguished:

- *Content tutor*
- *System tutor*

The *content tutor* is an expert in a subject or subject area who collaborates with the teachers; he/she is responsible for guiding the student along his/her chosen learning path and for facilitating the student's comprehension of the contents of each course. The content tutor is constantly at the disposal of the students; his/role includes acting as guide, and offering advice and study support to facilitate learning and in-depth comprehension of the course contents.

This activity must be carried out, first and foremost, through the creation of asynchronous interactive virtual learning spaces, such as structured forums and cognitive maps, or wherever necessary through synchronous tools, in order to focus attention on the topics highlighted as being the most important for each subject.

With the supervision of the subject expert, the content tutor will take care of all the activities concerned with both intermediate and final assessment, collaborating wherever necessary in the processing of online learning tests and examinations.

The person covering this role must have transversal skills with particular emphasis on the capacity to work in distance and online conditions and to handle interpersonal relationships such as group dynamics; it is also important for the content tutor to possess good communication and negotiation skills in indirect communication and in the management of document systems.

The *system tutor* accompanies the student throughout the entire learning path, from the first contact during which he/she receives all the information relative to the study course that he/she intends to follow, up until the moment in which his/her learning path reaches its conclusion.

The system tutor is expected to take care of orientation, that is, the distribution of the topics covered by the study courses and the teaching methods applied, and he/she is also expected to follow the student also during the fulfilment of the bureaucratic obligations required to enable attendance of the course selected.

The personalisation of the learning paths requires that research be undertaken right from the initial phases of course implementation with a view to gathering the greatest possible amount of information on the personal characteristics of the students. Among his/her various duties, the system tutor is also responsible for the collection of data relating to personal details and academic qualifications and for entering them in a computerized database with a view to gaining knowledge on user type. The system tutor is also expected to collaborate in the structuring of informative documents online (such as, for example, Web pages) gathering teaching materials and all the general information relative to the course, and making it easy for users to consult them via the internet.

The system tutor constantly monitors the individual and overall progress of the students through direct meetings, telephone calls and through the Net for the purpose of reducing the dispersion and dropout rate typical of this kind of study course and facilitating the conclusion of the academic path within the set timescales. Monitoring of the learning process takes place through continual feedback with regard to attendance and the number of examinations passed, on the quantity and quality of online interaction and on the observance of learning-related deadlines.

This reference figure represents the main interface in the teacher-student relationship and is responsible for helping overcome any communication difficulties that might arise and for resolving any organisational or learning-related issues.

When study courses provide for internships, the system tutor will be responsible for finding companies prepared to accept students while, at the same time ascertaining, through suitable tools, the type of internship that best matches the student's expectations and abilities, and then following up the latter's integration in the company by continuous monitoring of his/her activities.

Within the framework of the system tutor function, the *company tutor* is responsible for accompanying the student throughout the internship phase and during that of his/her entry and integration into the professional world; his figure represents the link between the company and the training body, in our case the University. Together with the person appointed by the company, he/she sets out the specific teaching goals and the school/work alternation schedule, identifying the activities pertinent to the professional internship. In order to cover this role, it is essential to have the prerequisites required for the system tutor together with corporate business experience.

The teaching methodology area must also include a series of coordinating figures dedicated to process management. More precisely, the following figures have been outlined:

- *Web-tutorial coordinator or master tutor*: this figure is responsible for coordinating online tutoring and for dealing with matters relating to the organisation and control of the teaching activities carried out by the content and system tutors with the aid of the appropriate software and online tools. This professional figure is responsible for training tutors relative to online tools, monitoring and reports with regard to the data produced by the information flows between the various players involved in the e-learning training process. In addition to in-depth knowledge of tutorial activities, his/her skills also include specific knowledge on the possibilities presented by interactive environments and ways of using them to advantage, as well as on methods and techniques for analysing document and information flows.

- *Assessment sector coordinator*: manages a group of training process experts who deal with performance assessment research, particularly on the subject of distance learning. He/she also takes part in the planning and development of research related to the countless issues posed by a sector such as distance learning and teaching innovation. Part of the experts making up this group must be online assessment process experts or assessors. In addition to consolidated experience in the performance assessment area, this professional figure is called upon to provide assistance to the scientific and teaching coordinators and to the tutors on the preparation of the performance assessment tools required for the "internal" assessment of the courses and the final assessment geared to optimise the quality of the learning path.

The following figures complete the professional profiles involved in the teaching methodology area:

- Editor
- Web-editor
- Web supervisor

The *editor* covers functions such as the designing, editing and updating of the document systems of the organisation responsible for providing and managing the courses. The blended learning teaching method, applied and tested by CARID, is based on indirect communication, that is, on interaction which, for the most part, is not characterized by the simultaneous presence and direct dialogue of the teachers, but managed through the conveying of documents. Therefore the production of documents in the context of transmission of knowledge by means of "distance" technology becomes extremely important. Such production differs from the use of teaching aids during traditional teaching inasmuch as it does not aim at in-depth analysis and supplementation of classroom communication but rather at its substitution (only as far as the conveying of knowledge is concerned: educational interaction is realized through the profitable use of specific software tools that lie outside this area). The responsibilities of the editor, in collaboration with the content experts, involve the designing and editing of teaching units in paper format, structured according to a precise method geared to facilitate the student's use, guiding the latter with regard to the contextualisation and comprehension of the topics covered, or in audio-graphic format, that is, intended to simulate the lesson through the synchronized combination of audio recordings and graphic diagrams corresponding to visual aids such as transparencies or blackboard, or, alternatively, in audiovisual format, in the form of recorded lessons, or in other multimedia, hypermedia and interactive formats. This figure is required to have skills in the area of indirect communication and document system management.

The *Web-editor* covers the same functions as the editor, specifically as regards the types of documentation that can be successfully used online. The Web-editor is therefore assigned—during the various phases of implementation and updating—to the design and management of digital documents to support online learning, that is, mainly documents produced using mark-up languages such as HTML, XML, SVG and SMIL through the use of standard desktop publishing technologies, graphics and hypermedia navigation, as well as those relative to the CMS (Content Management System) that supports the specific course. The Web-editor is, therefore, expected to have similar skills to the editor as regards document production and to possess specific knowledge on online communication and Website management, although not purely from the software development point of view, as this latter skill is required of other professional figures with whom the Web-editor is required to collaborate.

The role of the *Web supervisor*, (or *Web content manager*), defines the figure responsible for the content and information aspects of the course management organization's supporting Website. This figure is present in all organisations, teaching-related or otherwise, whose communication is characterized by the use of online digital technologies. All other editorial and technical roles involved in the management of the Website report to this figure: the skills required of this professional profile are those intrinsic to online communication, but from a methodological as opposed to a technical standpoint. This is, therefore, a person with a humanistic background, cultural communication skills and basic knowledge of technical language.

THE FIELD OF ANALOGUE, DIGITAL AND ONLINE TEACHING TECHNOLOGIES

This environment includes all those technical and technological professional profiles that are indispensable for the provision of online training or DL.

First and foremost, the professional figure of the *digital graphic designer* has been identified as being indispensable for the production of blended-learning teaching documents, inasmuch as he/she has the capacity to produce particularly complex, advanced communication aids such as bi- and tri-dimensional images and animations which considerably improve the conveying and comprehension of those contents that are suited to this type of representation, thereby improving the learning proposal from the point of view of the usability of the teaching materials. This professional role is purely technical and requires precise graphic skills and knowledge of the use of software tools for the development of 2D or 3D images and animations.

Also identified was the figure of *Web-developer***.** This person is responsible for the static part of the Website's structured documentation, taking care of the technical aspects of composition, formatting and presentation. He/she is also responsible for the production of digital documents that are then placed on the Website to be downloaded by the students. This is a key role in online teaching as the person covering it is responsible for the smooth running of Web interaction, a fundamental element in the assessment of the quality of the learning proposal. The technological skills of this professional figure range from the creation of bitmap images and photo retouches to the use of desktop publishing software, from audio duplication to the production of slides, tutorials, storyboards and other forms of teaching documentation.

To complete the figures making up this group, there are, on the one hand, technicians/engineers and, on the other, coordinating figures who are not only fundamental for the efficiency of the technological processes but also for their efficacy. In conclusion, it is important to highlight the presence of three different sectors, each of which requires a coordinator and a technical figure:

- Computer science sector
- Audiovisual sector
- Multimedia sector

The role of the *computer science sector coordinator* corresponds to a professional figure with the capacity to organize the activities of the computer science engineers, that is, supervize the design, construction and management of interactive communication processes and the production of dynamic documents on the Website. He/she is responsible for the engineering of the site and the programming of all of the software tools required for the correct running of the functions and organisational activities connected online and distance learning. His/her knowledge should correspond in substance to that of the computer science engineers. Additionally, this figure should be able to process and pursue together with the staff that he/she coordinates, the research and development strategies aiming at the progressive improvement of the technical backup to the teaching activities and at the integration of these two areas of knowledge.

The role of the *audiovisual sector coordinator* corresponds to a professional figure with the capacity to organize the activities of the audiovisual production technicians, script writers, audio and video operators and film editors, that is, all of the figures involved in the design, construction, normalisation and reviewing processes of audiovisual documents produced in analogue and digital formats.

The role of the *multimedia sector coordinator* corresponds to a professional figure with the capacity to organize the activities of the digital graphic production technicians, Web-developers and multimedia technicians, that is, all of the figures involved in the design, construction, normalisation and reviewing processes of teaching documents produced in digital formats and used online or through the use of optical memory media (Poletti, 2006).

These coordinating figures refer to the respective technical figures. The *computer science engineer* is responsible for managing the datawarehouse and for implementing real-time reconstruction procedures of the dynamic documents on the Website. Learning interaction also uses dynamic management technology of online documentation, indispensable for the organisation of Web-forums for information exchanges, the issuing of training tests with feedback, the transmission of teaching aids, enrolment in workshops, seminars and examination sessions: these functions are generally implemented through the acquisition of an e-learning platform. The computer science engineer must be able to handle these tools but also to develop platform functionalities, through activities and be able to satisfy all of the students' interaction requirements. The skills required to be able to cover the role of computer science engineer consist essentially of being able to manage databases and having expertise in software development and programming activities.

The role of the *audiovisual technician* corresponds to a professional figure of a technical nature, able to use audiovisual production equipment: his/her specific responsibility lies in the shooting of audio video material and the production and distribution of clips and films (recording of lessons and seminars, documentaries, Web-tv experiments). His/her skills involve, therefore, the use of cameras and audio and television editing tools.

Last but not least, the *multimedia technician* has been identified as a liaison figure. This is a professional figure with a technical profile well acquainted with the use of analogue, audiovisual and especially digital document production tools: the specific responsibility involves post-production, digitalisation and duplication of digital and interactive audiovisual training materials. His/her skills must therefore be transversal to the audiovisual and digital technological spheres.

transversal to all of the training and research activities with skills that enable him/her to structure and process statistical models with a view to applying them to the assessment of the processes and quality of the distance learning.

CONCLUSION

Undoubtedly this logically-structured list of the professional figures required for the design, implementation, provision and management of a learning path proposed with integrated and multimedia DL technology is not—nor is it intended to be—comprehensive, but simply to stimulate reflection on the distinctive features of e-learning.

In particular, on the consideration that the management of e-learning is based, from the operational point of view, on a number of essential elements such as:

- Use of an LMS platform
- Use of teachers/content experts in a variety of roles
- Use of specific professional figures for online teaching
- Design and production of teaching materials

Although these elements have equal weight in the defining of the complexity of the management of e-learning, it seems of urgent importance to reflect increasingly more extensively on the subject of the specific professional figures required for online teaching, in the hope that such reflection may lead to the development of appropriate learning paths so that the necessary resources may be easily found (Maragliano, 2004).

In brief, therefore, the specific professional figures for online learning are:

- Teaching coordinators or managers responsible for the design and teaching-related organisation of the courses, in collaboration with the scientific coordinators;
- Master tutors, responsible for tutoring activities in the context of the individual courses;
- System tutors responsible for supervising the activities of the students throughout the entire course, offering them support both from the organisational point of view and in the development of their study course;
- Content tutors, specialists in the various spheres of knowledge characterising the courses and assigned to interact with the students during the introductory phase as well as during the phases in which the students assimilate the contents pertinent to their particular area of specialisation.

The results emerging which, departing from many and varied origins, have come to focus on these themes, must not only remain a common source of useful information but should also ensure that a teaching method based on online learning effectively uses the internet as the main tool through which these professional figures working in synergy—no matter where they are based—may be a resource for the entire world of teaching.

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KEY TERMS

Content Tutor: Expert in a subject or subject area who collaborates with the teachers holding the courses in that particular subject area. The tutor is responsible for supervising the student throughout the latter's learning path and facilitating the student's understanding of the contents of the individual courses.

Integrated Learning: A learning context which combines distance learning with full immersion meetings (seminars, workshops). Integrated learning guarantees optimization of the time available, limiting and concentrating the learning moments requiring physical presence and the reinforcing through DL strategies of learning and testing activities.

Structured Forum: The term "structured" means that the forums are divided into various types. In structured forums, the positioning of each intervention (whether it be a question, answer or contribution) within this structure, depending on the topic chosen—facilitates its traceability (in a nonstructured forum containing thousands of interventions, the user cannot check whether the user's question has already been posed).

System Tutor: Professional figure that accompanies the student throughout his/her entire university course, from the first contact in which the information relative to the course of interest is provided right up until the discussion of the final examination.

Tutor: Professional figure assigned to artificially reconstruct the interaction processes with the student so as to eliminate the condition of physical detachment created by the distance teaching method.

Dynamic Reconstruction of Concept Maps

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INTRODUCTION

Within the e-learning context, the importance of developing concept maps—and, therefore, of developing software tools that support their design and utilization phases—clearly derives from their connection with the theme of the ontological structure of knowledge, which is founded on graph theory and which determines, according to rules defined by Joseph Novak (Novak & Gowin 1984), the node elements and the relationships with the arcs. However, concept maps cannot be described simply as a product of the evolution of the concept of content indexing, since their role encompasses not only the organizational function of knowing but also the vehiculatory function, assuming that there is a specific clarificatory task within the cognitive context that is different from, and additional to, the navigational support.

Research into concept maps takes its cue from the world of education (Novak, 1998), in which their significance is clearly recognized. On the one hand, the characteristic representation of the tissue of relationships that links the concepts together constitutes an extremely interesting expressive approach in terms of its capacity to focus attention of learners, whereas on the other hand—and mainly within the framework of constructivist didactics—the environments used for the ontological mapping of disciplines can be deployed as a locus for collaboration in exploring the cognitive and negotiative context. Both of these aspects are further promoted by e-learning (Canas, Hill, & Lott, 2003; Canas, Hill, Carff, Suri, Lott, & Eskridge, 2004), which uses concept maps not only in the representation of knowledge within a range of structural Learning Object models (Information Maps, Generative Learning, Workflow-based Learning) but also in the indexing of communication flows (Barabasi, 2004), and within interactive environments geared towards the collaborative construction of knowledge.

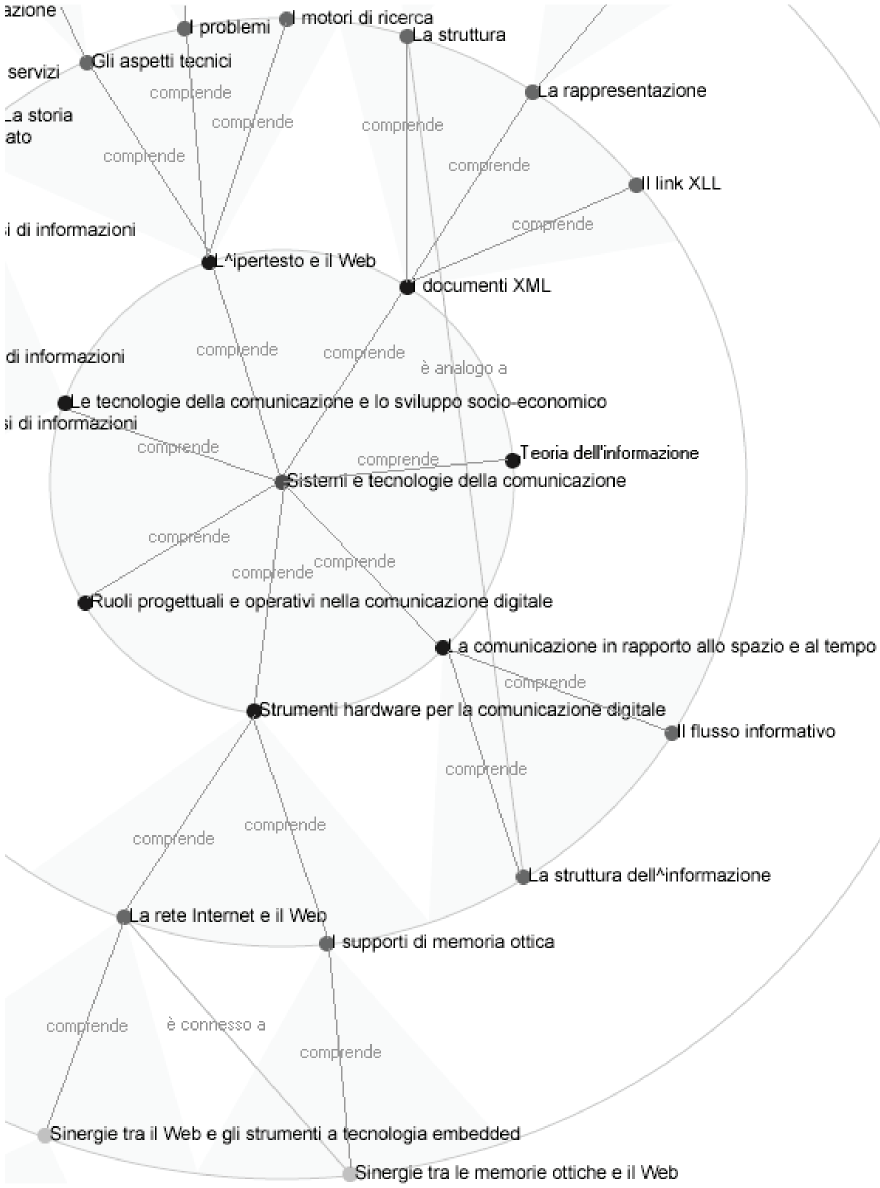
MAPS AS DYNAMIC DOCUMENTS

Concept maps, then, are used to represent cognitive structures in order to support the management of knowledge that is particularly significant in terms of the communicative and educational potential of its content (and also to explore and exploit that content collaboratively), but in order to optimize its communicative effectiveness and efficiency (Tamayo, 2004) it is necessary to use software tools that allow for its automatic reconstruction/updating and also permit visualization from multiple points of view through the application of rigorous, automatable, graphic representation algorithms (Kremer, 1994), that can take the place of the onerous task of manual design using graphic tools. Concept maps reconstructed using automated procedures are, therefore, dynamic (Tillman & Wissmann, 2004), meaning that they are part of a far larger set of "dynamic documents", which are documents produced in real-time at the user's request and which introduce information extracted from databases within formatted templates (most Websites include dynamic documents generated using various technologies—search engines being among the most common examples of dynamic content).

It is the sheer complexity and centrality of the representational aspect within the context of knowledge management that requires the use of tools which can graphically reconstruct concept maps through automated actions that based on the information contained in the Knowledge Management support databases (and, therefore, in large part, by the organization's Data Warehouse) and using online technologies are able to reproduce the schema of elements and relations in any situation in which this function is necessary, without recourse to manual operations (Pedroni, 2005).

Other tools, which go beyond the limits of manual design, allow for the dynamic structuring of online concept maps: this research has produced four models of automatic composition for concept maps, corresponding to four different reconstruction algorithms and to four different graphical forms. Some of these models

Figure 1. Proximal development in concentric circles graph



can be reconstructed on the basis of a predefined or random distribution of concepts within the documented space. Some of them feature two-dimensional graphics, whereas others have three dimensions but, in any case, as virtual objects, they are susceptible to variations in the viewing angle. These models, which have online functionality, collect data from a DBMS and compose images of maps that can be viewed in the browser and are responsive to the input of information, meaning that they are capable of supporting functions of navigation or didactic interaction, either in SVG format, or using a vector graphics mark-up language derived from XML and produced as standard by the W3C Consortium, or inside a Java applet. Within the context of training processes, their use is linked in particular with the functions of content structuring and organisational aggregation of the documents and learning objects to support the teaching activity.

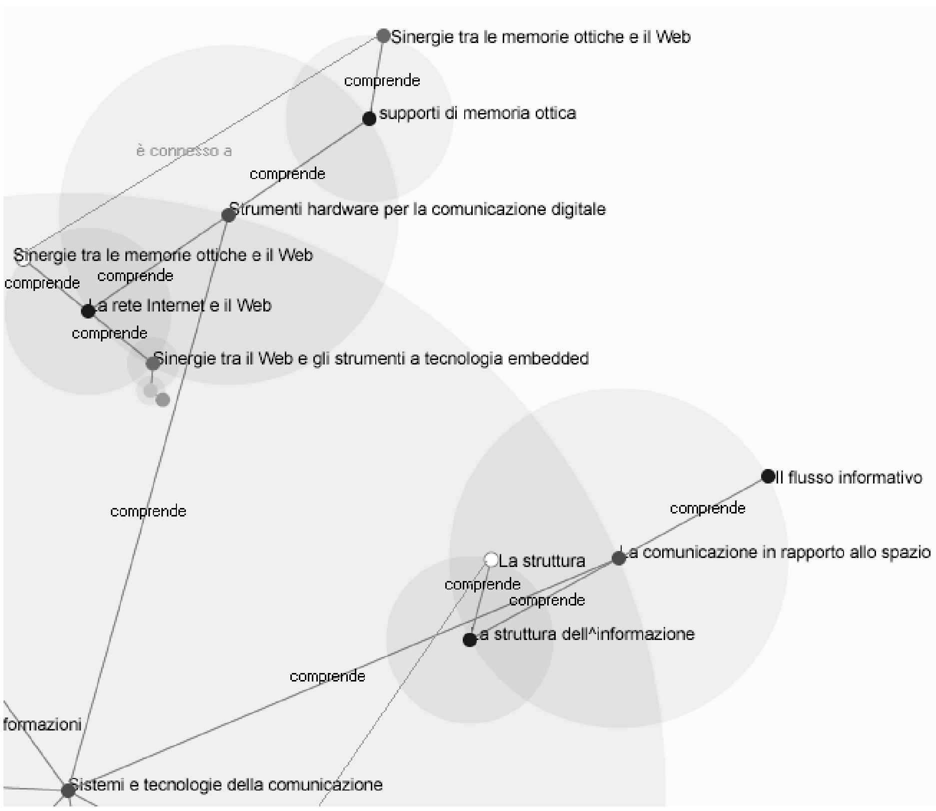
"Proximal Development in Concentric Circles" Graph

The rigorous construction for the figure of the graph is based on concentric circles, which allow for the distribution of the nodes in proportion to their distance from the original node. Choosing the "root" node ("root" being an appropriate terms to describe this tree-like structure) is an essential element in the graphic construction process. Having selected the root node, the process then entails the distribution of the connected nodes on a circumference that has, at its center, the root node. From this starting point, the procedure replicates itself by distributing—on a circumference that is concentric to the preceding one—new nodes connected to the nodes located on the first circumference, thus giving rise to a radial pattern.

"Proximal Development in Hierarchical Circles" Graph

A second rigorous procedure for reconstructing a graph, which is highly effective in terms of communication, is based on tracing an outline of the context of each node, starting (as with the concentric circle process) from a root node, around which are positioned (on the circumference), the nodes relating to the topic linked to the root, and connecting the nodes to the root through segments placed in a radial pattern. From that point on, every node is considered as a central node in the system, which constructs a second circumference around itself (with a lesser diameter than the one before), displaying the linked nodes and mapping out new radial segments.

Figure 2. Proximal development in hierarchical circles graph



"Proximal Development Three-Dimensional Rotable Conic Structure" Graph

The third procedure, which is the algorithmic reconstruction of the cone graph, is mostly a middle way between the techniques of reconstruction based on hierarchical or concentric graphs. Following the creation of the first circumference around the central node and the arrangement of the nodes to which the "root" node connects, the image widens out by means of the calculus of the expansion circumference of the "seed" nodes and the positioning of the nodes derived from them on the external semi-circumferences. The fundamental aspect of this reconstruction is the reintroduction of the third dimension at any distance from the root node, the depth of the image increases in size by a fixed amount, thus generating a conical shape.

The structuring of proximal development concept maps involves the repetition of constant patterns (concentric circles, hierarchical circles, cones) that serve to highlight the network of relationships from a perspective that perceives a certain node as the original, root node; the fact that this node is, in the previous models, interchangeable with all the others, renders the maps polymorphous but does not overcome their incapacity to do without a single origin.

"Gravitational Development Three-Dimensional Initial Random Distribution Rotable Structure" Graph

It is not easy to imagine a non-manual distribution of the nodes on the concept map that has the potential to overcome the limit of proximal development and the arrangement of the nodes on the basis of an original "pivot" node, yet this difficulty can be resolved very effectively if the branches are assigned a value, a pair of values or other quantifiers and qualifiers to determine the degree of intensity or attraction between the nodes that are linked by the connecting branches. Taking this as the starting point, and adding to the information base for the dynamic reconstruction of concept maps an indicative value for each relationship defining the degree of attraction between the two concepts, a fourth model has been created. This model, based on a Java applet software model, distributes the nodes—within the context of the document—in a random arrangement and subsequently moves them around until an acceptable configuration is reached.

CONCLUSION

The most evident aspect of these modes of representation of knowledge in map form is the visual impact of the graphical object, which is characterised by the capacity to vehiculate a complex message, such as the highlighting of the tissue of concepts and relations that supports a cognitive context, through a symbolic structure that is characterized by automatic replicability. Over and above the importance of the question of the rationalisation of the productive activity of the map, it is worth focusing, in conclusion, on the consequences of reconstructive rigour when exploiting that productivity.

At first glance, a map that has been designed manually can appear easier to interpret, but it cannot guarantee that same uniformity of representation that results from the rigour of the reconstructive algorithm, even after structural modifications and expansions. Moreover, manually designed maps do not afford the same plethora of perspectives deriving from polymorphic recomposition, which are the result of the variation in the root node. Lastly, manual maps do not offer interactive modification of the perspective, whereas several of the models presented do.

Dynamically reconstructed concept maps demonstrate their communicative effectiveness in e-learning, thanks to the constant, multiple uses of the graphical tool generated by the user, who, through this document, interacts with the knowledge context.

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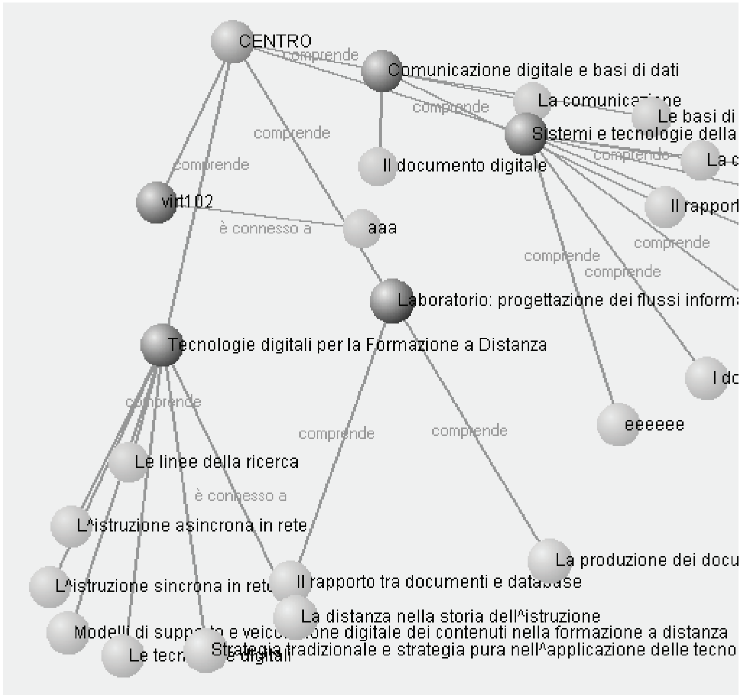
Figure 3-4. Proximal development three-dimensional rotable conic structure graph, and the same graph after a rotation



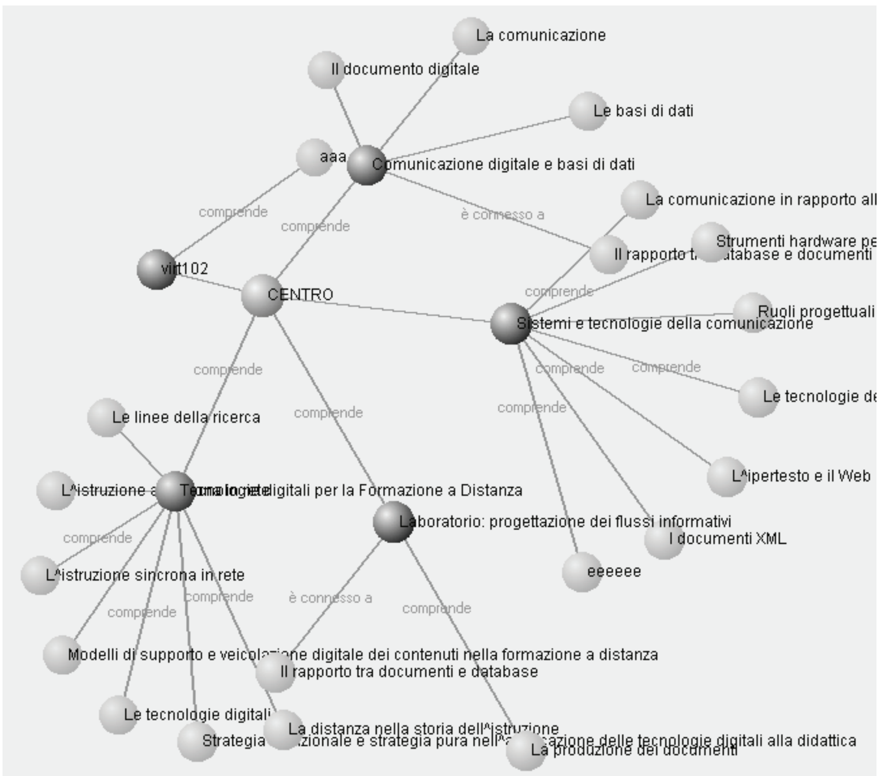
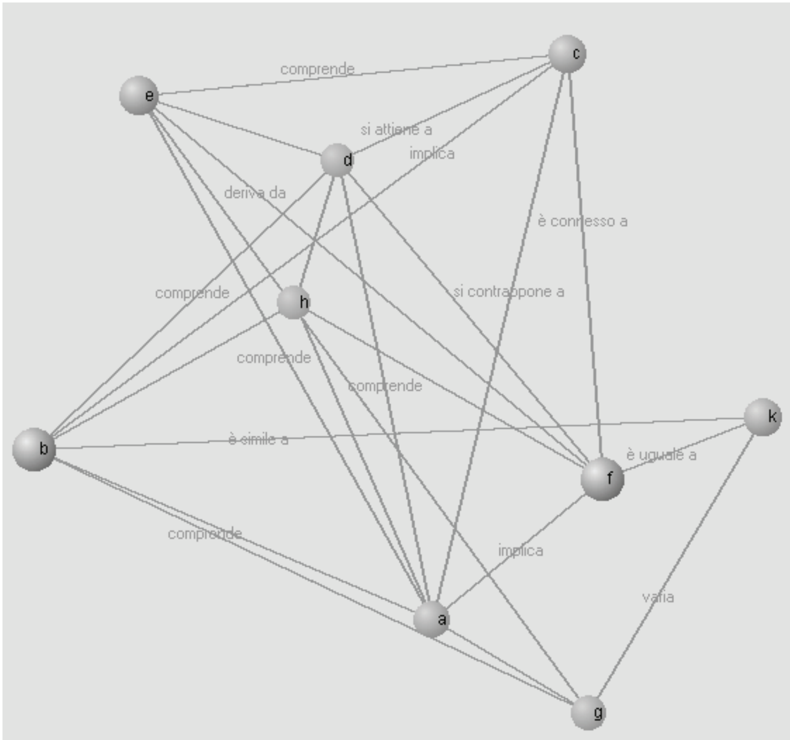


Figure 5. Gravitational development three-dimensional initial random distribution rotable structure graph



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KEY TERMS

Concept Maps: A method of document production defined by J. Novak in the second half of the 20th century and based on the expression of assertions. These assertions are transformed into constructions of the entity/relation type, in a graphical form that recalls graph theory, in which the nodes are the concept elements (grammatically, nouns, and adjectives), the arcs are the relations (grammatically, verbs, and adverbs), and both graphical symbols are always accompanied by a label that displays their contents.

Data Warehouse: A set of archiving systems for company data in digital format, notable for its capacity to store historical data relating to the organisation's activities (production, marketing, administration) and to make them available for querying for statistical or decision-making purposes (driven by the decision support system software). The presence of a data warehouse within the organization is a fundamental condition for implementing knowledge management practices.

Dynamic Document: A document characterized by its nonpermanent status, that is, it is not intended to carry out archiving functions but simply to communicate information to the requestor. It is necessarily a digital document, in that it is generated by automated software that collects the information from a database and then inserts it into a preset template. Many online documents (including search engine pages) are, in this sense, dynamic.

E-Commerce Recommendation Systems

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INTRODUCTION

In the last decade electronic and wireless technologies have changed the way companies do business forever. E-commerce (electronic commerce) and e-business (electronic business) feature as extremely dynamic economic sectors and at the same time, as the most appealing ways of beginning or expanding a business activity. Successful companies today recognize these technologies and the Internet as mainstream to business success. Indeed, their future will continue to be promising to companies seeking means for cost cutting, enhanced productivity, improved efficiency, and increased customers' satisfaction. On the other hand, this networked economy is notably characterized by the impersonal nature of the online environment and the extensive use of IT (information technology), as opposed to face-to-face contact for transactions.

Since Internet technologies and infrastructures to support e-commerce are now in place, attention is turning to psychological factors that affect its acceptance by online consumers and their perceptions of online transactions. One such factor is *individuality* of e-customers, seen to be key to the proliferation of e-commerce. The demand for better products and services has been a pressing need. The question is how easily Internet users become e-customers and which are the internal "mechanisms" and external factors that participate in an e-purchase. The problem arises from the fact that the shoppers have varying needs, preferences, and background. At the same time, they are confronted with too many options and information that they have to deal with, the majority of which is often irrelevant to their needs and interests. In most cases, search engines are used for filtering pages according to explicit users' queries. However, their results are often poor since the produced lists are long, unmanageable, and contain irrelevant pages (Middleton, De Roure, & Shadbolt, 2004).

Currently, successful e-commerce strategies have focused on personalization technologies and opportunities. According to Personalization Consortium (2006):

"personalization is the combined use of technology and customer information to tailor electronic commerce interactions between a business and each individual customer". In other words, it means "gathering and storing information about web site visitors and analyzing this information in order to deliver the right content in a user-preferred form and layout." (Braynov, 2003)

Personalization is expected to be one means for pushing e-commerce and e-business forward. In this direction, the recent web technological advances help online companies to acquire individual customer's information in real-time and with low cost. Based on this information, they construct detailed profiles and provide personalized e-services. Thus, e-shops have now greater potential for increasing customer satisfaction, promoting customer loyalty, establishing one-to-one relationships, and consequently for return on investment.

The most popular forms of personalization are *recommendation or recommender systems (RSs)* (Adomavicius & Tuzhilin, 2005). They have emerged in the middle of 1990's and from novelties used by a few Websites have changed to important tools incorporated to many e-commerce applications (e.g., Amazon.com, eBay.com, CDNow.com). Specifically, these systems take advantage of users' and/or communities' opinions/ratings in order to support individuals to identify the information or products most likely to be interesting to them or relevant to their needs and preferences.

In this chapter, we investigate the way RSs support e-commerce Web sites in their attempt to convert visitors to customers. We present the background field, compare the latest RSs and describe a general process for RSs. Finally, we illustrate the future trends and challenges and discuss the open issues in the field.

BACKGROUND

The dilemma of how to choose the most suitable products and services is a challenging research problem. Various approaches have been used to produce recommendations. Initial efforts were limited to *check-box personalization*, where portals allowed the users to select the links they would like on their "personal" pages, for example MyYahoo! (Manber, Patel, & Robinson, 2000). This has proved deficient since it depends on the users knowing in advance the content of their interest. Moving towards more intelligent approaches, *collaborative filtering (CF) or social filtering* (GoldBerg, Nichols, Oki, & Terry, 1992; Jung, Na, & Lee, 2003) typically based on product ratings explicitly defined by the users. The system recommends items that have been evaluated positively by similar user(s) whose ratings are in the strongest correlation with the current user. CF tries to model the way people take recommendations from friends, which would be the ideal situation. Its advantages include the capability of application in cross-domain recommenders and the simplicity compared to other recommendations techniques, as it does not need feature extraction, item representation, and so forth, but only ratings. Its drawbacks include the so-called "new-item" problem where a new item is not recommended unless a notable number of users rate it, the more common "new-user" problem, where a new user is registered and has not rated enough items so that the recommender can make accurate recommendations and the sparcity problem, where the number of available ratings are much larger than the ratings to be predicted by the recommender. CF is also vulnerable to attacks from vicious users for example promotions of an item or nuking.

Another approach is *content-based filtering* (Sarwar, Karypis, Konstan, & Riedl, 2000; Jung et al., 2003) that uses product features and recommends products to users that have similar features with those they rated highly during the past. It has some problems same with CF and some of its own. As it is based on item-to-item filtering, sometimes the recommendation results lack diversity. The feature extraction process when it comes, for example, to multimedia content can be rather difficult and a proper representation for the objects is not easy. The "new-user" problems still exist here. However, content-based filtering can work more easily with implicit feedback methods like keeping record of the purchase or search history, compared with CF, which most of the times needs explicit ratings of items.

Besides these two techniques, *demographic filtering* employs demographic data (e.g., gender, age, education, profession, etc.) to infer recommendation rules based on stereotypes. However, there are issues here about how the user information will be obtained and about the privacy policy of the company towards the customers. Privacy issues are common in demographic filtering and CF methods. Lastly, *statistics-based methods* (e.g., best-sellers) provide no-personalization but their results can be appreciated by users while they are easy to implement. Many systems incorporate them into their recommendation strategy as a stable technique. Due to the shortcomings of each recommendation method, *hybrid models* (Burke, 2002) have been proposed in order to combine the robustness and eliminate the drawbacks of the individual techniques. In the next tables a comparison of the most recent RSs is provided.

RECOMMENDATION SYSTEMS' PROCESS

Even though RSs are complex applications that combine several models, algorithms, and heuristics, most of them perform the basic steps of the knowledge discovery in databases (KDD) process. This process includes the following steps: data selection, data pre-processing and transformation, data analysis, interpretation and evaluation, and presentation (Geyer-Schulz & Hahsler, 2002), as depicted in Figure 1.

Table 1. Comparison of various RSs

Recommendation Systems	User-item matrix	Feature vectors	History of purchases	Demographic features	Stereotyping	Training set	Manual	IR techniques i.e. TF-IDF	Clustering	Classifiers	Explicit feedback	Implicit feedback	Semantic feedback	Domain knowledge	Weighted	Mixed	Meta-level	Cascade	Feature augmented	Switching	Feature combination
MovieMagician (Grant & McCalla, 2001)	√							√			√		√	√					√		
CFCB (Melville, Mooney, & Nagarajan, 2002)	√							√		√	√								√		
Recommendz (Garden, 2004)	√										√		√		√						
Cinemascreen (Salter & Antonopoulos, 2006), (Cinemascreen, 2006)	√										√								√		
PTv (Smyth & Cotter, 2000)	√	√								√	√	√				√					
Quickstep (Middleton, 2003)	√					√	√			√	√	√		√					√		
GBHA (Huang, Chung, & Chen, 2004)		√	√								√									√	
TechLens (Torres, McNee, Abel, Konstan, & Riedl, 2004)	√	√						√			√					√					
Viscors (Kim, Lee, Cho, & Kim, 2004)	√		√				√		√		√							√			
Stef (Guo, Zhang, Chew, & Burdon, 2005)	√	√									√			√	√						
Fdras (Jung et al., 2003)	√					√			√		√				√						
Windowls (Kazienko & Kolodziejski, 2005)	√				√					√	√				√						

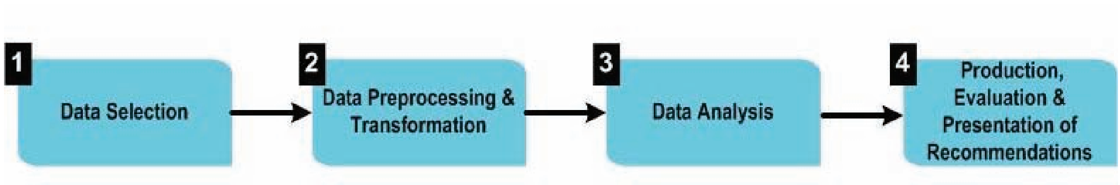
Table 2. Specific features for RSs comparison

Column	Description
User-item ratings matrix	Matrix storing the historical user ratings.
Feature vectors	Vectors of features that represent an item. The vectors store usually an integer or Boolean value that indicates the amount of a feature in an item.
History of purchases	Historical data usually in forms of listings.
Demographic features	Demographic data about users, for example, age, sex, occupation, and so forth.
Stereotyping	Use of demographic features to build stereotypes in order to classify users in certain categories.
Training set	A set of examples to initialize the profile of a user or to train a classifier.
Manual	User sets his own parameters.
IR techniques	Information retrieval techniques, for example TF-IDF algorithm.
Clustering	Grouping.
Classifiers	Neural nets, decision trees, association rules, and so forth.
Explicit feedback	User provides explicitly information.
Implicit feedback	User behaviour is observed and information about the user is inferred.
Semantic feedback	User provides information about particular features of the items he prefers.
Domain knowledge	Uses domain knowledge.
Weighted	Uses weighted combination hybrid.
Mixed	Uses mixed combination hybrid.
Meta-level	Uses meta-level combination hybrid.
Cascade	Uses cascade combination hybrid.
Feature augmented	Uses feature augmented combination hybrid.
Switching	Uses switching combination hybrid.
Feature combination	Uses feature combination hybrid.

Data Selection

This step refers to the selection of the data set that will be used to produce recommendations and can stem from various sources. Collecting accurate and sufficient data comprises a crucial task of every RS. Specifically, it can include data about the *user* (demographics, user knowledge, skills, capabilities, interests, preferences, goals, etc.), the *usage* (selective actions, ratings, usage frequency, action correlations or sequences, etc.), and the *usage environment*, hardware, software and physical (browser version, available plug-ins, bandwidth, display/input devices). These data can be collected either *explicitly* (the user is asked to provide them using questionnaires, fill-in preference forms, etc.) or *implicitly* (the data are derived without initiating any interaction with the users using acquisition rules, plan recognition, and stereotype reasoning). However, in both approaches, we have to deal with different but equally serious problems. In the case of explicit profiling, users are often negative about filling-in questionnaires and revealing personal information online, they comply only when required and even then the submitted data may be poor or false. On the other hand, in implicit profiling, even though our source of information is not biased by the users' negative attitude, the problems encountered derive once again from the invaded privacy concern and the loss of anonymity. Personalization is striving to identify users, records their online behavior in as much detail as possible and extracts needs and preferences in a way they do not notice, understand or control (Kramer, Noronha, & Vergo, 2000; Mesquita,

Figure 1. RSs' process



Barbosa, & Lucena, 2002). The most important data sources that a RS can use are: registration, login/password, history file, navigation, search keywords, support, product/service evaluation, etc.

Data Pre-Processing and Transformation

The next step in the recommendation process after data collection (a task that is in continuous execution) is data preparation that involves data cleaning and data transformation into internal representation models that will allow for further processing and updating. Data cleaning removes all irrelevant entries from the web server logs in order to facilitate their manipulation. For instance, entries that do not reveal actual usage information are removed and missing data are completed. Moreover, data compression algorithms can be used in this stage in order to reduce the size and dimension of the data and achieve efficient mining of the patterns. The problems that we face often during this phase include: *user identification*, *session identification*, *path completion* and *transaction identification*.

- **User identification:** Registration and login/password procedures, as well as the combination of other heuristics, can be used for assuring the identification of unique users.
- **Session identification:** Session is a set of user clicks across one or more web servers and session identification aims to group the page accesses of each individual user into sessions. Time windows can be used to identify the different sessions of a user.
- **Path completion:** This problem is caused from local cashing and proxy server activities creating gaps in the users' access paths. Referrer log for identifying the page that the request came from and also the site topology can be used to fully cover this issue.
- **Transaction identification:** This problem (grouping the references of each user) can be solved by using time windows that partitions a user session based on time intervals (specified thresholds).

Then the map of the data into required structures can be performed. These models can be either *individual* or *aggregate* (when working with groups of users) profiles.

Data Analysis

Then the application of statistical and data mining techniques follows, in order to detect interesting patterns in the preprocessed data. The most well known techniques used for data analysis include *clustering*, *classification* and *association rules mining*. A more detailed description of these techniques follows.

- **Clustering:** Clustering algorithms are used mainly for segmentation purposes. Their aim is to detect "natural" groups in data collections (e.g., customer profiles, product databases, transaction databases, etc.). They compute a measure of similarity in the collection in order to group together items that have similar characteristics. The items may either be users that demonstrate similar online behavior or pages that are similarly utilized by users. The produced groups (database segmentation into clusters of similar people, e.g., customers, prospects, most valuable or profitable customers, most active customers, lapsed customers, etc.) can be based on many different customer attributes (e.g., navigation behavior, buying behavior or demographics). There are several clustering algorithms available: hierarchical agglomerative clustering or HAC, k-means clustering, self-organizing maps (SOMs) or Kohonen (Chakrabarti, 2003).

- **Classification:** The main objective of classification algorithms is to assign items to a set of predefined classes. These classes usually represent different user profiles and classification is performed using selected features with high discriminative ability as refers to the set of classes describing each profile. This information can be used to attract potential customers. Unlike clustering which involves unsupervised learning, in classification a training set of data with pre-assigned class labels is required (classification is categorized as a supervised machine learning technique). Then the classifier (by observing the class assignment in the training set) learns to assign new data items in one of the classes. It is often the case that clustering is applied before classification to determine the set of classes. Some widely used classification algorithms are: K-nearest neighbor (KNN), decision trees, Naïve Bayes, neural networks (Chakrabarti, 2003).
- **Association rules mining:** Association rules connect one or more events. Their aim is to discover associations and correlations between different types of information without obvious semantic dependence. In the Web personalization domain, this method may indicate correlations between pages not directly connected and reveal previously unknown associations between groups of users with specific interests. Such information may prove valuable for e-commerce and e-business Web sites since it can be used to improve customer relationship management (CRM). The most well known algorithm for discovering association rules is Apriori (Agrawal & Srikant, 1994).

Production, Evaluation and Presentation of Recommendations

After data analysis, the extracted knowledge has to be converted into intelligent information, interaction, or interface for each customer. In this step the found patterns should be interpreted in order to be understandable to the users. Indeed, every pattern comprises a separate e-marketing opportunity and its validity, novelty, and usefulness should be evaluated and managed differently. Finally, the RS presents the produced recommendation in a suitable form. Their purpose is to provide access to specific items through promotional links, such as those that are supplied for instance by cross-selling or up-selling options. For example:

- **Cross-selling:** It suggests products related to the one(s) the user is currently viewing. In many cases, these are complementary products. For example, proposing a music CD with a book or batteries with toys.
- **Up-selling:** It suggests products perhaps more expensive or advanced to the one(s) the user has chosen. The customer will be informed about products available in the next (upper) price level, which the customer may not have known about. The degree of applicability of this tactic depends on the type of products and this also applies to cross-selling as well.
- **Opinions of other customers:** It suggests additional products that the customer may also like to purchase, based on what other customers (considered as like-minded) have bought.
- **History data:** Analyzing the history of past purchases (stored in a transaction database), the e-shop is able to offer customers a targeted range of choices that are most likely to fit their profile.

FUTURE TRENDS

This section reviews some of the main aspects of RSs that need more research, the optimization of which can lead to better results. These include the RS's interface, the privacy problem, the recommendations' validation problem, the shilling attacks problem and the usage of decentralized architectures and location-based services for more advantages.

One of the most important elements of a RS is the interface. In order for a customer to trust the system, the interface should be comprehensible and the system functions should be transparent to him. New ways also have to be invented so that customers are encouraged to give feedback. Schafer (2005) with DynamicLens presents a dynamic interface in which, one can instantly see the result sets as one changes the recommendation parameters. Visualization techniques can also be used in order to represent the profile information like stated by Middleton (2003) or even a whole product taxonomy to acquire more easily user feedback.

A permanent issue in RSs is privacy. Surveys have shown that customers hesitate to disclose personal data in fear of how the companies will employ them. Privacy policies found in most sites are awkward and extended and customers either don't have the time to read them or they are not willing to. Moreover, some customers don't recognize or understand the value of personalization provided by the Web sites in return for the personal information. Kobsa and Teltzro (2005) presents an alternative way of communicating the privacy statements with the customer, which offers better results. The privacy policy is broken into pieces and is distributed to the context that each piece refers to. Each time a customer is asked to provide a bit of personal data, comprehensive information is given about how the data will be used and why they are needed. The communication of privacy policy is one step towards acquiring the trust of customers.

Trust is also an issue when it comes towards the results of the RS. Lots of times, recommenders suggest unreasonable products to customers. Such situations make customers lose their trust on the site and abandon it. Pazzani (2005) proposes more sophisticated algorithms than can comprehend the user goals and relate them to a well-built common knowledge representation. O'Donovan and Smyth (2006) give a solution to the first aspect, which promotes interactivity with the user in order to elicit the current need of the customer instead of guessing a recommendation. A dialogue-based recommendation can figure out whether user's focus has changed context and it can assist a user lost in the information, while a wrong guessing can result in losing the customer.

Another important issue is the security of recommendation techniques. Recent work like the one presented by Lam and Riedl (2004) has disclosed the vulnerabilities mainly of collaborative filtering to attacks. An attack can either target an item promotion, called a push attack or an item degrading, called a nuke attack. The attacker can promote an item by creating fake user profiles and providing high rating to it and most common ratings in the other items, so that the attacked profile or the attacker is highly correlated with most users or user profiles. The way the attacker chooses to interact with the system in order to transform the system's behavior is called attack model. Burke, Mobasher, and Bhaumik (2005) provides a survey of the attack models and identifies the six dimensions in attacks; the data sources, the recommendation algorithms, the profiling algorithms, the detection of attacks, the response to the attacks and lastly the evaluation of the damage the attacks cause. Future focus will concentrate in enhancing the robustness of current algorithms in attack detection and the invention of metrics that can evaluate the change that has been caused by an attack.

The emergence of the semantic Web and the wide usage of other decentralized infrastructure like the grid or peer-to-peer systems will also influence the development of recommender systems. Most implementations so far are based on simple client-server architecture and therefore centralized, that is a server performs all the computations and stores all the data. The adoption of a decentralized model (Ziegler, 2005) has multiple benefits. Firstly, decentralized infrastructures can give a solution to the problem of privacy as both data storage and calculation can be done locally on each network node. Also, a central service provider is not necessary as network nodes function independently. Through their own sites or homepages, organized in a machine understandable form, information can be acquired about user preferences and trust circle by means of links to other sites. Lastly, speed and scalability problems, which exist in current projects, will dissolve.

As mobile computing grows exponentially, recommendation techniques are evolving to take more parameters into consideration. With GPS technology, recommendations in the spatial domain can be done. For instance, a restaurant recommender can use collaborative filtering and a content-based algorithm to recommend restaurants nearest to the customer that fit his taste. Also, the time parameter can be used in combination with the customer's location in order to provide one-and-only items, as for instance, a gallery occurring in a certain time period at the customer's location. So, location-based recommenders are highly recommended for tourism applications. Of course, this kind of services also raises some important issues like privacy concerns, especially when the profile information is stored in a central node.

CONCLUSION

Recommendation systems are special personalization tools that help users find interesting information and services in complex online shops. Even though today's e-commerce environments have drastically evolved and now incorporate techniques from various domains and application areas, setting up a successful recommendation system is not a trivial or straightforward task. In this chapter, we presented the importance of RSs for intelligent e-commerce web sites, compared the latest RS, explored the different steps of recommendation process and concluded by discussing some open issues in the field.

E

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KEY TERMS

Collaborative Filtering: It is the method of making automatic predictions (filtering) about the interests of a user by collecting taste information from many users (collaborating).

Content-Based Filtering: It uses product features and recommends products to users that have similar features with those they rated highly during the past.

Demographic Filtering: It employs demographic data (e.g., age, profession) to infer recommendation rules based on stereotypes.

Hybrid Approaches: It combines various methods to produce recommendations in order to combine the robustness and eliminate the drawbacks of the individual techniques.

Personalization: It is a set of techniques and services that aim to solve the information overload problems Web users face, by providing them with what they want or need, without having to ask (or search) for it explicitly.

Recommendation System: It is a program which attempt to predict items (movies, music, books, news, web pages, etc.) that a user may be interested in based on various information, for example demographics, transaction history, navigation, and so forth.

Education and E-Learning Evaluation and Assessment

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INTRODUCTION

The assessment of e-learning shares most of the needs and requirements of face-to-face teaching, including clarity of the main objective, needs analysis, comprehensibility of objectives, definition of resources, and balance report (Calvani & Rotta, 2000). However, in e-learning environments the qualities of both monitoring and formative assessment have prominence, and can even determine the success of the course (Moore & Kearsley, 1996).

In the *learner-centered* approach, typical in e-learning, the student is the protagonist of the teaching-learning process and thus, assessment is considered from a new perspective. It can be defined as the systematic process of correction, revision, collection, and use of information regarding both the students and the course in order to favor the progress and the learning of each student (Palomba & Banta, 1999). Assessment and evaluation are two different concepts even though they are interconnected: the former determines the student's knowledge, skills and attitudes while the latter is necessary to express an opinion on learning results and on the quality of teaching.

ASSESSMENT OF E-LEARNING

According to the leading experts in this field, the assessment of e-learning is a key process which not only evaluates the coherence between the objectives achieved by learners and what has been planned in terms of content and methods, but also monitors the dynamics of the process. In this way, it is possible to obtain useful information to replicate the formative action and/or make it more flexible.

The assessment of online training courses refers to various aspects (Fragnito, 2002):

- Learning assessment
- Process assessment
- Course evaluation
- Interaction assessment
- E-learning platform assessment

In the *learning assessment*, based on timing and content, it is possible to distinguish:

- *Diagnostic assessment* of which the aim is to identify students' background knowledge and/or their needs in order to personalize teaching and to set up a suitable learning program;
- *Formative assessment* of which the aim is to highlight the knowledge, competencies and skills acquired by each student at the end of each teaching module;
- *Summative assessment* of which the aim is to check the level of competencies and skills at the end of a course or to evaluate the effectiveness of the formative action. It must include several tests administered both during and at the end of a course.

The *process assessment* is intended to test the efficiency and the effectiveness of the managerial and organizational variables as well as of all those aspects which can be involved when developing and teaching a course. This kind of assessment can make use of a questionnaire to gather information referring to the students' reactions to the training experience and to produce useful feedback on what the course has meant for the students. Teaching effectiveness and the training process are closely linked because a deliberate teaching plan can be critical for the students to reach the course objectives. As a result, student evaluation of learning means assessing the validity of the teaching process.

The *course evaluation* is divided into three phases. The first is *ex-ante* and it refers to the identification of a series of indicators which are evaluated by a financial body on the basis of the planning prospect target of the institution that proposes the course of study. The purpose of the other two phases, *in-itinere* and *ex-post*, is to identify the discrepancies and the conformities between the planning proposal and the implementation of the plan. In particular, the formative assessment (*in itinere)* can be divided into learning assessment (*effectiveness*) and process assessment (*efficiency*). As far as the latter is concerned, two different kinds of data exist: the objective data are provided by the organization which offers the course (obtained through the official reports that are submitted throughout and at the end of the course) and the subjective data which are provided by the students (gathered through questionnaires) who express their opinion about:

- Instruction (competence, effective timing, interest in the contents, clarity and articulation of topics);
- Course structure (presentation, articulation of contents, timeliness);
- Teaching material and contents (conformity to the course's general objectives and to the students' background knowledge);
- The e-learning platform adopted (functionality, clarity, and intuitiveness);
- The experience (pros and cons of the course).

Both during *the interaction assessment* and the *e-learning platform assessment*, it is necessary to emphasize that integrated e-learning environments are mainly based on written and asynchronous communication which provides the possibility to pair collaborative learning with *learning by doing*. These environments are generally used for social-constructivist learning processes where a virtual community collaborates in the development of mutual products or interaction about the course topics. Technological equipment used for this process must be able to support each of the necessary practical activities (exercises, simulations, etc.). It is important to verify immediately what the participants have learnt. Assessment is also based on the observation of the interaction among participants and on their means of collaborating and learning together. A balance between tests based on quantitative aspects (the number and distribution of messages in diverse work areas) and qualitative ones (content of messages) is fundamental. In analysing several online training experiences, it can be emphasized that the best results from the learning perspective are obtained when a frequent and positive collaboration between the instructor and the students (vertical interaction) is achieved in addition to frequent communication between the students (horizontal interaction) (Bocconi, Midoro, & Sarti, 1999).

The interface in virtual learning environments should be intuitive and friendly so that students' needs are facilitated by their use. Especially in the case of short courses, the time necessary to learn how to use the system should be proportionate to the course objectives. It is also important that the environment should offer a series of useful features for adequate support of the participant in the learning process.

TOOLS TO EVALUATE E-LEARNING

Some e-learning environments provide the possibility to track and elaborate a great quantity of information automatically thus making data collection easy, are very important. Moreover, one of the most important features of e-learning is the monitoring method that typically includes *tracking systems* and *e-portfolio*.

Tracking Systems

A tracking system is usually characterized by:

- The *login* accesses the e-learning platform which identifies the user, tracking the connection date;
- The *login session* allows measurement of the duration of the connection to the e-learning platform by the user;
- The *visited areas* of the platform allow monitoring of the areas visited by the user during the login session;
- The *testing evaluation* scores the tests completed by the user;

- The *training course summary* provides overall data about the course attended by the user.

By tracking individual logins to the e-learning platform, it is possible to measure the frequency distribution of contacts within a fixed time interval (per week, per month, per year) and the reason for the login (downloading material, establishing contacts with the instructor, chatting sessions, taking part in discussion forums, etc.). The information that is gained from the tracking facilities indicates whether the login trend has been constant and if it has followed the insertion of the material provided by the instructors or if there has been a particular concentration activity during certain periods (for instance before the final exam). It is clear from the tracking process whether the user logs in only to download the course material, or to post an answer to the instructors or to actively participate in the virtual community while developing a cooperative learning experience.

Through *text analysis of forum discussions and chats* it is possible to understand the dynamics of the user's learning process and of the gradual progress of the community.

Tracking data and the analysis of the materials are fundamental to evaluate the project as a whole as well as the online activities of each student. Interpretative models as well as algorithms are necessary to go beyond the single numerical datum, in order to consider the quality of online activities and data relationships, and to integrate the quantitative analysis of online activities with the semantic analysis of written texts. At the same time it is necessary to develop models of online interaction typologies through which it is possible to establish the planning and the realization of interoperating and customizable environments. One of these methods of analysis is the *social network analysis (SNA)*. It is a quantitative-relational analysis of the interaction flow and, unlike traditional quantitative methods based on the characteristics of each participant (sent messages, received messages, etc.), it is based on relational data: connections, contacts or links that characterize a group of people or of organizations (families, associations, societies, countries, etc.) (Scott, 1997; Wasserman & Faust, 1994).

As already stated, in e-learning, the construction of knowledge is not only achieved through the activity of the single user but through the participation of a virtual community with which it is possible to share competences and knowledge, collaborating with the others to reach the same goal. The SNA permits the description and analysis of the structure of interaction to be considered during exchanges within a group or in a virtual community, evaluating the impact each has on the relational structure and observing the effectiveness of the role models (tutors, moderators, etc.) as they interact and communicate. Moreover, the SNA can be a useful instrument for the tutor to monitor while developing the process of cooperative knowledge construction. In particular, the SNA identifies some critical moments of group dynamics (isolation, attention catalyzation, non-mutual interaction) that should trigger immediate intervention by the instructor in order to quickly make any necessary modifications to the program.

Another important aspect of SNA is the option to display the relationships and communication among the different net components called knots through the use of diagrams, graphs and maps by using a tool such as *NetDraw*. Furthermore, it is possible to study the factors that influence the relationships among the knots by considering, for example, the age, the context, and the background of the individuals involved in the analysis. This study can be carried out by using traditional statistical techniques such as the correlation, the analysis of variance, the factor analysis, and so on.

ELECTRONIC PORTFOLIO

A portfolio is a useful instrument to evaluate learning and there are a variety of portfolios.

It is possible to describe the portfolio as a *profile* containing a list of certificates and credits obtained during an individual's school years and any possible certification of training and work experience. However, it is also possible to consider the portfolio as a *portfolio of competencies* which allows the documentation of an individual's particular learning process. This model produces a personalized interpretation of learning and provides the opportunity to document, evaluate and create awareness of the acquired competencies. From a didactic point of view, the interest in the portfolio is related to the way in which teaching is planned with an emphasis on a personalized, learner-centered approach and reflection. The way through which the portfolio develops in addition to the role of the student may change the purpose of the portfolio from an instrument used for the documentation and evaluation of the processes to a tool used to acquire awareness of the process (Rossi, Magnoler, Blam, & Alessandri, 2004).

In e-learning, the portfolio is called *e-portfolio* (*electronic portfolio*). It consists not only of the simple reproduction of a paper-based portfolio in a digital format but also allows the user to collect digital artifacts, to share them and to connect them in reticular structures.

A standards-based e-portfolio makes use of a *database* and *hypertext links* to identify the relationship between the appropriate goals of the course and the final artifacts. As Barrett (2000) says it is important to not only collect artifacts but also to document a process that evolves dynamically over time in order to study its evolution.

Many e-portfolios are based on the model first used by Danielson and Abrutyn (1997) and then revised by Barret (2000). This model consists of the following fundamental steps:

1. **Collection:** A description of the artifacts to be collected by students will be evaluated by the tutor/instructor on the basis of the portfolio's audience, purpose and future use of the artifacts.
2. **Selection:** A selection of the materials chosen by students to be included in their portfolio according to certain criteria that reflect the learning objectives established for the portfolio. The tutor/instructor directs students in making the choices so that the materials are representative of the level of learning achieved during the course.
3. **Reflection:** An overall review by the students of the collected material which allows reflection on each piece in their portfolio. The self-assessment brings added value to the review process.
4. **Projection/direction:** Students review their reflections on learning and set new goals for the future. They receive feedback which is useful to direct their competencies.
5. **Presentation:** Students share their portfolios and request feedback from others. Documents are converted into a format which allows hyperlinks.

As already stated, if the portfolio is useful to document individual competencies, an e-portfolio allows students to connect materials situated in different files and retrieve any work that is considered meaningful both in their own course and in those of the other students or instructors. This process results in the assembly of newly synthesized materials that can be compared and interpreted. In this way, it is possible to *personalize* the process and learning increases through sharing and the construction of meaning.

TOWARDS AN INTEGRATION OF E-LEARNING AND E-ASSESSMENT

By accounting for the socioeconomic theory according to which the training and assessment process is divided into different phases, Kirkpatrick's (1994) four-level model is a truly appreciated approach that utilizes:

- **Reactions:** A measurement of how well the students enjoyed a particular training program (customer satisfaction);
- **Learning:** What competencies the students have absorbed;
- **Application:** Students' ability to transfer and apply new competencies;
- **Impact:** The result of training as it relates to effectiveness and efficiency.

In e-learning, assessment needs to be re-defined according to new learning scenarios. Various scholars have attempted to describe the quality of training experiences from a cognitive perspective. Savery and Duffy (1995) underline that the concept quality of learning is possible when:

- The student is actively involved in the learning process;
- The student constructs the student's own knowledge;
- The student acts at a metacognitive level;
- Social negotiation is involved in understanding.

According to the constructivist perspective, the importance of evaluating learning from the learner's viewpoint has gained a new value after changes which have occurred in traditional teaching. Learning is considered the result of internal and external factors which are inextricably woven together and which involve the learner in the training process. In this case, methods that bring instructors and evaluators closer to the learner's point of view may be required. It is also necessary to let the instructors and evaluators recognize that the interpretation of the learner's performance is effected by their own experience.

Within a learning community, the importance of understanding learning from an "internal" viewpoint is further strengthened. Some experts (Henry, 1992; Henry, Charlier, Daele, & Pudelko, 2003) underline that in order to support effective training courses, it is necessary to establish an assessment dimension, negotiated by the community, which reflects the idea of assessment as a knowledge process. Thus, the process of assessment means truly understanding the new learning scenarios.

Quality of learning is connected to individual and collective experiences validated by the course community (instructors, designers and students). As a consequence, learning is the result of a group process where the students both as individuals and also as members of a group learn through the adoption of new practices. This process is not only active but also reflexive. Learning assessment is based on individual and group reflections as well as on the suitability and accessibility of knowledge and materials and also on the concrete realization of what has been learned.

The significance given by each participant to the training experience emphasizes the need to focus on the evaluation of its quality and the fundamental factors in the development of a learning community. Active involvement of the students in the discussion and in metathinking regarding the training process is fundamental to obtain a valuable review of the ongoing process.

Supporting the student in becoming an effective thinker is a useful strategy to adopt. In this way, he/she may evaluate the learning process by reflecting on the online experience and focusing his/her attention on the social interaction that facilitates the e-learning process in group settings. Metathinking leads to a clear awareness of individual needs within the community structure. It aids in the definition of a common goal and emphasizes the possible achievements of the student as a result of his/her being a member of a community.

A metathinking approach should contain two different aspects of learning: *learning in a virtual community* (interaction and group activation, communication mediated by the computer, including an instructor role) and *contents learning* (effectiveness of activities and an ultimate satisfaction of expectations).

Without doubt, the element that influences the community is *emotional involvement*. The sense of membership, encouraged by the course activities and by tutor messages, is a fundamental element for the course success.

CONCLUSION

Everything considered, recently there has been an increasing interest in e-assessment. It is necessary to go beyond a purely mechanical assessment of the skills of a student, since the entire process of learning has been placed in a relational dimension and in a precise environment where motivation can affect the course results.

There are different ways to control a face-to-face training session. In contrast, it is possible to monitor, check and evaluate the entire e-learning process thanks to the data generated by the virtual platform. However, only taking into account the data concerning the standard objective tests would mean ignoring the cooperative and dynamic essence of a course.

In e-learning, assessment processes are essential because they turn the scrutiny of the course evaluation from collateral and/or final activities to ones that may have continued throughout the course. Additionally, the assessment changes from being other-directed to a co- or self- managed practice. As a consequence the goals and the evaluation criteria are shared by all the actors involved in the learning process (Varisco, 2004). Thus e-assessment also incorporates the *context* of a course, and is considered fundamental in an environment constructed to facilitate learning.

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KEYWORDS

Assessment Item: A questionnaire, a test or any other activity used to evaluate whether a student has achieved the objectives that have been established.

Chat Room: A virtual place where Internet users meet and communicate in real-time using instant messaging applications.

Forum: An asynchronous online communication environment consisting of virtual message boards where it is possible to leave messages in order to create a new discussion or to reply to a pre-existing one.

Practices: Any activities that allow students to put into practice the knowledge and skills acquired through the study material. These activities include case studies, exercises, quizzes, tests, laboratories, simulations, and so forth.

Self-Assessment: The educational process involving students who make judgements about their own level of knowledge and competencies.

Survey: The technique used to collect data useful to acquire homogeneous answers to specific questions. It can be conducted by direct or telephone interviews, paper questionnaires, online forms, and so forth.

Tracking: The process of recording the training path followed by a student in a training management system. Tracking allows the instructor to constantly monitor the students' training activity.

The EduOntoWiki Project for Supporting Social, Educational, and Knowledge Construction Processes with Semantic Web Paradigm

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INTRODUCTION

The Web is going to produce a revolution in learning and teaching: the debate on the role of ICT in educational processes leads to a reconsideration of how we deal with information and knowledge. The widespread use in educational contexts is also due to the ease with which learning resources can be retrieved and shared: for example, the recent introduction of learning objects means that the contents which reside in different e-learning platforms is easy to find and access. But knowledge is also deeply embedded in millions of Web pages. Nonetheless, searching for information on the Web is not a simple task and the great number of documents found using search engines, such as Google, is beyond the human cognitive capacity to deal with this information overflow. Teaching information literacy skills or stimulating collaborative information filtering that supports the discovery of resources in a way that is responsive to the context of users may help, but there is a need for more efficient cognitive tools to search, organize, and discuss information in order to codify it in shared knowledge structures.

In a more and more complex world we need support to think at a high level so the technologies let us develop strong knowledge structures that do not have the representational problems of the old schemas. An attempt in this direction is the Semantic Web: if we succeed in making the Semantic Web available and useful for education, it could revolutionize the way we think about teaching and learning with ICT. Our current research is aimed at the development, experimentation and evolution of an integrated learning environment called EduOntoWiki that is backed up by a semantic structure based on the active consent of communities of practice.

BACKGROUND

Current research suggest that it is not correct to assume that the introduction of ICT necessarily changes the way students learn. We have to acknowledge that the teacher plays a critical pedagogical role in creating the conditions for technology-supported learning through selecting and evaluating appropriate technological resources and designing learning activities (Galliani, Costa, Amplatz, & Varisco, 1999). We can distinguish between two approaches to ICT: a technology-centered approach and a learner-centered approach (Mayer, 2005). The former generally fails to lead to lasting improvements in education: looking back at the many predicted educational revolutions, in which the current "new" technology (radio, television, computer, multimedia, the Web) would have been the "killer" application for teaching and learning processes, we see that they failed to materialize (Cuban, 1986) and so was the case with the claims and worries, during the 1960s, that computers-as-tutors would replace teachers (Cognition and Technology Group at Vanderbilt, 1996). A learner-centered approach can, on the other hand, help students and teacher to learn and teach through the aid of technology with a focus on how ICT can be used as an aid to human cognition and consistent with the way the mind works solving complex tasks and dealing with today's information overflow. The quantity and kind of information students today need to assess has expanded exponentially in the last few years, due mainly to the World Wide Web and improvements in the capabilities of search engines. In this context, it is important to consider both student and teacher roles using a constructivist approach that can stimulate collaborative formalization and knowledge building.

SEMANTIC WEB AND ONTOLOGIES

The Web has arrived at an important epistemological crossroad and there is a need to integrate the current dialogic-informative model, which allows us to interact with people and search for documents on the Web, with a model based on the contextual knowledge domains within which we operate: the Semantic Web approach (Berners-Lee et al., 2001). Both models are strongly based on a learner-centered approach so the applied research, in particular in the field of ICT and educational technologies, is moving in two directions:

1. The development of solutions for information exchange, and in general, for intelligent knowledge management;
2. The development of a collaborative/cooperative approach to knowledge building.

The Semantic Web was coined by Tim Berners-Lee to refer to a vision of the next evolution of networks that can add meaning to the navigational context of the current World Wide Web. It is the new-generation Web that makes it possible to express information in a machine-interpretable form, ready for software agents to process, as well as to understand what the terms describing the data mean both on the syntactic and semantic levels (Hendler, 2001). An important role in the development of the Semantic Web is played by ontologies (Gruber, 1993). The term is borrowed from philosophy but it is used in a different and more pragmatic sense: they are an explicit specification of a conceptualization, that is, a formal description of concepts and relationships that can exist in a knowledge domain, that is intended as a knowledge base to be shared and re-used in the real world. These ontological structures will, for instance, allow us to no longer surf the universe of documents on the Web through hypertext links from text to text, but from concept to concept; or even to retrieve information in a relevant way without the "noise" that characterizes search engines. In order to achieve this aim, formalized languages have been created (XML, RDF) to mark texts semantically. These languages, which are able to codify knowledge through domain ontologies, can be easily understood both by humans and by ad hoc programs such as semantic browsers (Dzbor, Domingue, & Motta, 2003) or by specific software agents.

The importance of ontologies has been recognized in different research fields, and even from an operational point of view the current application areas are different: from medicine to knowledge content standardization, from legal information systems to biological and geographical information systems, from e-commerce to natural language processing, and finally education (Devedzic, 2004). Our current research project is aimed at extending and integrating the construction and evolution of a semantic learning space that is backed up by ontological structures relative to educational sciences (Petrucco, 2003) based on an active consent of communities of practice.

THE EduOntoWiki PROJECT

The different training and background of those who contribute to educational theory, the different cultures they belong to, and the rapid development of scientific work today require the development of a series of shared conceptual schemas. It is important then to generate these schemas not as general principles but as justified, motivated, documented and finally usable schemas as control "criteria" of pedagogic discourse. As an ontology is basically a conceptual organizer of scientific discourse, it is a formidable support to hermeneutic work.

Within this context we developed the idea to build an ontology of education. The project takes into account the state of the art of educational research in Italy, France, Spain, Germany, England and Spain. The three thematic areas studied, at least in this first step of the project, are: *didactic planning, educational communication,* and *assessment* and *evaluation*. The ontology is "negotiated" in working exchanges and dialogical moments in order to develop a circularity of information flow within the virtual community of the experts involved in the project and other actors participating.

The project has been developed with the immediate aim of building an integrated semantic learning environment called "EduOntoWiki" (http://multifad.formazione.unipd.it/eduonto), a wiki-based environment where it is possible to construct, discuss, and contextualize ontologies suitable for describing the actors, processes and technologies of educational sciences. A wiki was chosen because it enables easy and immediate insertion, modification and sharing of texts and materials by a community of users (Wikipedia is a good example) and because it gives freedom over the knowledge creation process to users. The recent promising research in the application of the semantic Web to wiki software (Campanini, Castagna, & Tazzoli, 2004; Hepp, Bachlechner, & Siorpaes, 2005; Scaffert, Gruber, & Westenthaler, 2005) confirm this decision.

Indeed, our initial vision conceived the instrument as a tool to help in the creation of an ontology and the description of a specific knowledge domain mediated by a discussion within a community of practice. To be really useful an ontology requires the active consensus of a committed community of practice in a knowledge domain (Domingue, 1998; Trentin, 2004) as experts of do not always completely share the same categorizations, interpretations and distinctions. Often this is not only because of the reciprocal irreducibility of fundamental theoretical orders, which is both physiological and necessary, but rather because of the confusion created by the different meanings given to "key" terms in the discipline in question.

If it were possible to have an "ontological" reference model with shared lexis and semantics, as regards both terms and their relations, this would probably help to reduce conflicts which arise from misunderstandings and incomprehension. Ontologies created in this way would also have a significant side-effect for all the actors involved: first of all the definition of a common lexis (Wenger, 1998), then a strong push towards the conceptualization of tacit knowledge, and finally the sharing of a metamodel in which processes, knowledge and relations are shared. Defining ontologies which support educational applications based on the Web is therefore no simple task, above all because of the difficulty in formally conceptualising a domain which has always played on the idiosyncratic interpretation of each philosophical/pedagogical approach.

Ontologies would be useful not only to the academic community, but as far as their didactic use is concerned, we can think of an ontology or a series of "educational" ontologies, that could be used and discussed by students, teachers, and people interested in the real world of applications and training contexts. This "open" ontology paradigm can offer considerable advantages. For example, it could provide a medium which would foster the sharing of the basic knowledge in a discipline and a place where students could easily find educational resources (learning objects) with a strong context relation to the subject. Today the learning objects paradigm means that the contents which reside in the different systems used in e-learning platforms, need to become reusable, accessible and interoperable. Each object therefore needs to be described beforehand by others through unambiguous formalisms (so-called LOM, learning objects metadata) so that people can retrieve them more easily. But this retrieval paradigm is often wrong: the meaning of the metadata must be shared by most communities of users possible and this is not the common case. The practice of describing resources may at first appear to be simple and straightforward, however, when a system of description is analyzed deeply it becomes evident that it is actually ambiguous. The use of metadata presupposes not only a set of logical relations but also a specific vocabulary generally agreed upon by a linguistic community (Downes, 2004). Ontologies, integrated with social tagging processes (i.e., folksonomies) (Mathes, 2004), could indeed offer a strong support for solving this problem because every learning object would be *embedded* in the structure of the ontology itself; in this sense there is a side-effect that consists of the collaborative setting up of a learning object repository that uses the ontological base for "intelligent" consultation. Learning objects have always existed in teaching: in their practice, educators operate within a deconstruction and reconstruction process of materials and resources, but what is missing is often a conceptual and disciplinary framework to go back to, which, in today's world, could be easily accessible and consultable through the Web. It is precisely this that the various domain ontologies could provide.

The wiki interface of the ontologies is well suitable for developing a constructivist environment, where people of a learning community can add and modify the concepts dialogically (Souzis, 2005). If we then assume that the learning process is never confined to the materials used in an online course, but that it is also fruit of the interaction among the members of the group, with the wiki-based ontologies we provide a *scaffolding* (Devedzic, 2004) which will facilitate communication and the construction of meaning among all the actors involved (academics, teachers, tutors, students) and at the same time represent the structure and contents of the discipline.

FUTURE TRENDS AND DEVELOPMENTS

As ontologies in EduOntoWiki will be the result of the active involvement of both a community of practice of academics and actors from different educational fields (teachers, students and trainers), the social/relational aspect which turned out to be increasingly significant in the course of this research, led us to systematically further the study of the relationships within a community, as well as between different communities, in relation to the knowledge construction process supported by the wiki-based software. We want to verify how this environment can ease knowledge construction and formalization as "instance" from different communities of practice interacting together. In fact, the direction that the most promising, current research is taking involves the study of so-called "complex constellations of communities of practice" (Wenger, 2004). This definition has been used to describe the special relationships which unite various communities and render them permeable in such a way that they can reciprocally share knowledge, contextualizing, and enriching it with new meanings, thus favoring creative solutions to complex problems.

On the basis of these premises, we will seek to verify whether a social theory of learning can effectively lead to the overcoming of rigid borders between training/educational systems, work environments and social activities. In this sense, we can try to "free" learning so it is no longer seen to be linked to a specific area or moment of one's life, but actively constructed in the inter-community interactions of a lifelong learning continuum.

What will be investigated in particular are the negotiational interrelations between people who, in various forms, are members of different communities, people who share an active interest in all training environments and who bring valuable examples of "good practice" even if they belong to different work contexts. This aspect, led us to expand a new learning dimension, aimed at stimulating reciprocity, transferring and recontextualization processes, insofar as learning is recognized as a social/relational process, and the multiple contexts where learning takes place that becomes a precious alternative representation (Lave, 1988), effectively expressed by the learning subjects by means of a narrative description (Bruner, 1996) that a rigid codified ontology formalization would, on the contrary, risk penalizing. Narrative is used in education and training contexts to motivate and to illustrate, the reason for this is that the cognitive structures we use to understand the world around us are similar to the cognitive structures we use to understand narratives. It is assumed that the interaction, comparison and reciprocal recognition of the different communities involved will succeed in triggering off a virtuous process of crossfertilization able to transfer skills, processes, and models.

An important challenge highlighted by a close examination of international research on this theme, is that inter-community relations are not easy to manage or formalise since the members can only count on relatively limited shared meaning and practices (Friesen, 2002). Interoperability among communities, which our EduOntoWiki environment wishes to foster, is thus closely linked to a negotiation of meanings, identities and roles. Identity and roles for example, can be formalized using the semantic standard FOAF, (friend of a friend) while other important personal relations are more difficult to express. Maybe the only way is to include the innovative approach of the folksonomies (Petrucco, 2006) and/or the creation of specific "instances" in the ontologies intended mainly as a narration of personal and contextual experiences lodged in a precise space, time and place. It is not by chance that social networking tools, such as LinkedIn, Friendster and Orkut, are now considered a necessary extension of the recent blog phenomenon. In fact, we intend to evaluate whether, and in what way, it is possible that this process of *narrative conceptualization* can lead from the formulation of "descriptive instances" to spontaneous formalization, on behalf of community members, of "normative instances", that is, knowledge models which can be reused in multiple experiential contexts for solving problems.

CONCLUSION

Our research group believe that the potential effects of the Semantic Web for the world of education and training, and in particular for e-learning, will certainly be positive, but only if governed by a strong pedagogical-methodological reference structure which facilitates integration of the new technological-semantic paradigm into the more recent social theories of learning. Given these assumptions, combining the Semantic Web with social software appears to be a natural choice: it can support the creation of semantically enriched content using simple interfaces and by allowing domain experts and novices, teachers and students to collaborate within rich inter-cultural communities, sharing their true life experiences. To conclude, while it is true that the EduOntoWiki project presents considerable challenges both on a technical-scientific and on a theoretic-methodological level as it attempts to integrate the most innovative instances of international research on the Semantic Web and on pedagogic research, we also believe that fast and complex contemporaneous social evolution necessarily requires adequate instruments able to interpret and manage it.

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KEY TERMS

Communities of Practice: Communities of practice are groups that form to share what they know and to learn from one another regarding some aspects of their work. People in organizations often realize they could benefit from sharing their knowledge, in-sight, and experiences with others who have similar interests or goals. For the most part, this process of informal gathering and sharing of expertise is a voluntary.

Folksonomies: Folksonomies are bottom-up taxonomies that people create on their own, as opposed to being created and imposed by a group or institution such as by professional librarians using complex and lengthy rule sets (e.g., Dewey decimal system or Library of Congress index). Synonyms include folk categorization, social tagging, and ethnoclassification. They are grassroots classification systems for data. The value in folksonomies is derived from many people adding their own tags. The more people tagging one object, the better, because it gives alternative ways of searching for and finding information.

LOM (Learning Objects Metadata): We can define metadata as "information about information", and a LOM is a metadata about a learning object that can refer to multimedia or digital educational resources. Sets of metadata are used to identify and meaningfully describe characteristics relevant to these resources, for example, the learning resource type, the intended end user, difficulty level, educational goal, and so forth. The Learning Technology Standards Committee (LTSC) give rise to the IEEE LOM (Learning Object Metadata) 1484.12.1-2002 standard of educational metadata.

Ontologies: An ontology is a formal representation of knowledge about an area of interest. The part of the world conceptualized or described is called the "knowledge domain." Ontologies provide a vocabulary for representing and communicating knowledge domains and a set of relationships that hold among the terms in that vocabulary.

Semantic Web: The Semantic Web is an extension of the current Web in which information is given a well-defined meaning, better enabling computers and people to work in cooperation. The mix of content on the Web has been shifting from exclusively human-oriented content to more and more data content. The Semantic Web brings to the Web the idea of having data defined and linked in a way that it can be used for more effective discovery, automation, integration, and reuse across various applications. For the Web to reach its full potential, it must evolve into a Semantic Web, providing a universally accessible platform that allows data to be shared and processed by automated tools as well as by people. [W3C]

Social Network: A social network is a set of people or organizations or other social entities connected by a set of social relationships, such as friendships, coworking or information exchange. The connections between them may show specific patterns and can be represented by graphs. Recently many online social networking sites have begun to flourish with millions of users describing themselves in terms of who they are, what music they listen to, what books they read, and so forth, and trying to discover other people with similar interests.

Wiki: A Wiki is a collaboratively-edited Website that uses a software publishing tool. The distinguishing feature of wikis is that they typically allow all users to edit any page, with full freedom to edit, change and delete the work of previous authors. Collaborative knowledge creation is thus a central aspect of a wiki system. Wiki pages are accessible and usable at any time, and the content constantly evolves. The first wiki was created by Ward Cunningham, and the word "wiki" came from a phrase in Hawaiian—"wiki wiki"—which means "quick". It's quick because the process of editing is entwined with the process of reading. Both are done using a standard Web browser. Unlike most Websites, there's no need to edit a file, upload it to a Web server, then reload the original to check it.

An Edutainment Framework Implementation Case Study

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INTRODUCTION

The convergence of information technology, particularly multimedia applications, has made it possible to create electronic games with characters that come alive on the screen. From its original use just for entertainment, electronic games now can be used for educational purposes. Thus, the term 'edutainment' is created from a combination of the two areas: education and entertainment. Exploring the edutainment environment has become an interesting research area and understanding its application to suit various learning environments or teaching models is a crucial issue.

Research has shown that educational games can be integrated in the learning environment, but the difficult part is to design edutainment products that reflect the goals of the curriculum. McFarlane, Sparrowhawk, and Heald (2002) assessed the knowledge acquired via the use of educational games in primary and secondary teaching. The study was based on teachers' opinions on the limits and potential of games. Their results reflect that most of the teachers had a very positive view of the adventure games and, above all, of the simulations. However, in spite of this very positive assessment, they stressed the difficulty of using these games in the teaching due to the pressure of time and the need to cover the educational program in its entirety. The requirements of the curriculum were also mentioned by teachers in the study by Sanger (1997). For this reason, it is important to have a design framework for edutainment environment that can show the merits of games to teaching staff and enable them to use them in a way that is oriented far more towards the acquisition of the knowledge required by the school content structures. Hence, this research attempts to refine the design framework whereby its implementation may overcome the current problems in an educational setting involving children ages four and above.

BACKGROUND

Edutainment can be defined as:

A place where children could enjoy what they learn with a combination of many mediums (sound, animation, video, text and images) by simply using a computer mouse to point and click on a particular picture, word, or button; and stories as well as information that will come alive on a computer screen. (Druin & Solomon, 1996)

To Buckingham and Scanlon (2000), edutainment is a hybrid genre that relies heavily on visual material, on narrative or game-like formats, and on more informal, less didactic styles of address. The purpose of edutainment is to attract and hold the attention of the learners by engaging their emotions through a computer monitor full of vividly coloured animations. It involves an interactive pedagogy and focuses on making learning inevitably fun. Edutainment environment has become immensely popular and commercially successful with parents, educators, and children. Research has shown that computers help children learn. The use of computer-based learning, or e-learning, was found useful with young children. Carlson and White (1998), for example, discovered that the use of a commercially available software program significantly improved preschool or kindergarten students' understanding of the concepts of left and right. Based on their findings, the researcher concluded that it is possible to provide young preschool children with a favourable computer experience while enhancing their understanding of a particular educational concept.

Two other studies support the conclusion that well-designed e-learning activities, when presented with the active participation of a trained tutor, can increase young children's cognitive abilities. Goldmacher and

Lawrence (1992) studied two groups of preschool children enrolled in a Head Start[1] program. One group followed the standard Head Start program while the other group participated in computer enrichment activities in addition to their standard Head Start activities. The computer activities were theme-based and built around a variety of software. Students in the computer or e-learning group demonstrated improvements in all academic skills tested and showed greater growth in memory and visual perception. Chang and Osguthorpe (1990) showed that kindergarten children who worked with a computer achieved higher scores in tests of word identification and reading comprehension than children who received regular noncomputer teaching.

However, not all of the educational software could provide positive effects on children. Haugland assessed the effect of developmental and nondevelopmental software on children's cognition, creativity, and self-esteem (Haugland & Wright, 1997). The nondevelopmental software is the drill and practice software which consists of multiple choice questions or quizzes presented using information technology. The result indicated that nondevelopmental software had a detrimental effect on children's creative abilities. Developmental computer experiences fit young children's style of learning because they provide children participatory learning experiences that are intrinsically motivating and tend to be holistic learning experiences. In evaluating approximately 750 software programs marketed for use by young children, Haugland found that most of the software is developmentally inappropriate. Only about 20% of the software meets young children's developmental needs.

Children learn best by doing, interacting, and exploring rather than watching and/or listening. Exploring, manipulating, and "playing" with materials are the most effective ways to teach young children (Kantrowitz & Wingert, 1989). Hence, edutainment which usually exists in the form of electronic educational games could be the most effective e-learning material to be integrated in the classroom, as by playing games, psychological needs of children can be fulfilled. Electronic games are undoubtedly motivating, thus the intrinsically motivating nature of the electronic games should be utilised by using this medium for educational purposes as it is no secret that motivation is the key to education. However, there are still many issues that need to be addressed in the design of edutainment environment. Hence, this research serves to refine the theoretical design framework of edutainment environment.

This research aims to provide the design framework for edutainment environment that is refined based on the literature review, analysis of existing edutainment products, and a case study that has been conducted on selected research settings. The objectives of this research are:

i. To link motivation with psychological needs and understand how edutainment can achieve these important aspects in learning
ii. To investigate current issues and problems pertaining to edutainment in the learning and teaching environment as well as to examine the extent to which edutainment reflects the goals of the curriculum
iii. To compare the application of practices for game design in the existing electronic educational games by analysing them based on a set of parameters of good game design
iv. To conduct a case study on selected research subjects for the purpose of refining the theoretical design framework
v. To refine the design framework that may be implemented to create an edutainment environment that reflects the goals of the curriculum

After the analysis has been performed on the selected edutainment products to discover the strengths and weaknesses based on several perspectives, the researcher conducts an empirical study[2] involving the same edutainment products that have been critically analysed to further refine the theoretical design framework for edutainment environment. Twenty-four preschool children and one educator from a preschool, located in a middle-class neighbourhood of Kajang under Cheras district in Selangor, participated in the summative evaluation. Participating children originated from the same cultural background. None of the participating children had used the four selected edutainment products before. All children were able to use the computer, as attested by their educator. The preschool had only one personal computer with different types of educational software that was demonstrated to the children and sometimes used by them in different sessions. The computer was used once a week for half an hour during the childen's computer lesson.

Three sources of data were used in the empirical study. These data sources include interview of children and educator, direct observation, and video recording. All the questions that were prepared in advance were posed to the children due to the fact that when children at this early age are involved in the research process, interview is the type of data collection method that is more suitable than providing them questionnaires to be completed. In some cases, instead of asking children one direct question, the researcher posed several questions asking about an issue from different perspectives. Children's related responses and reactions were combined to make a more robust overall measure of each issue. For instance, to assess children's affective responses towards the overall design of the game, several questions in the interview together with their spontaneous reactions were used to provide an affective index. These questions dealt with whether children liked the program and its features, and whether they enjoyed their learning experience in an edutainment environment. For the educator, the types of questions posed were more towards obtaining information on a certain set of criteria in educational game from her perspective. It is to be noted that although the questions were prepared beforehand, the educator was given much opportunity to express herself in issues that are not restricted by the questions prepared beforehand. Although the nondirective interview was implemented, the researcher is satisfied that the information is sufficient for the case being studied.

FRAMEWORK FOR EDUTAINMENT

As a sort of play for children, digital game-based learning from very humble beginnings, has quickly inserted itself at all levels of childhood and studenthood, from lap kids to grab students (Prensky, 2001). Sure, it is possible to criticize the design, methods, means, and even the motivation of its creation, as many do. The point is, though, that this is how 21st-century kids grow up. Kids love that they can control what happens on the screen. They quickly learn to turn on the computer by themselves, point the mouse, and use the computer.

Digital game-based learning, currently, is being used to teach mathematics, music, and so forth. The idea is to combine storytelling and computer games together to build a moral educative environment. The game should feel like a video game or a computer game, all the way through, but the content and the context will have to be cleverly designed to put the children in a learning situation on morality subjects. Designing feedback to be less learning-like and more game-like is often a big paradigm shift and challenge for digital game-based learning designers.

In a playful context, kids seem to have an almost infinite capacity for learning. It is very easy, it is effortless, and it is exciting. If you put them in some kind of game situation (a computer game or video game), they will pick up skills very quickly and learn how to do things at an amazing rate.

Motivation plays a central role in any learning activity. By playing educational games that are developmentally appropriate, children's psychological needs can be fulfilled as these games can provide a 'fun' and 'play' experience as discovered through the children's responses in the interview and reactions observed through observation and video recording, thus can be motivating for the children to learn the embedded learning content. The framework has been made based on the difficulty in helping children learn in two domains:

- **Motivation:** To motivate them to want to spend time and engage in learning activities
- **Psychological needs:** To aid them in cognitively constructing knowledge

On the other hand, the best practices for game design also have the influence in assisting children in their learning. Initially, in the researcher's opinion, the best practices for game design are meaningful storytelling and use of interactivity as a cognitive artifact as they are the focus of game design. However, attractive or nice interface and challenge driven mainly by a goal are also found to be the best practices for game design drawn from the results of this study. The advantages of information technologies such as multimedia applications that are used extensively in games development can be utilized to perform the edutainment environment. The edutainment products can be designed in one screen that hides incredible programming behind a simple façade for educators to customize different aspects of the games to better fit curriculum requirements.

Within the framework, game designers should apply the best practices for game design in developing edutainment products that enable the users (educators) to 'create their own games' for the children. According to Prensky (2001), tools can be included in games either as an integral part of the game play (to build own environment) or as supplements (design own characters or new levels). As such, game designers need not be concerned about the storytelling but could focus on other best practices for game design, namely, interactivity, interface, and challenge. By having the tool for this purpose, the users (educators) could put the content or storytelling element in whichever way they like without requiring them to have good programming background or technical knowledge. It is believed that it could resolve the problems faced with existing edutainment products, especially with regard to the incomplete or unsuitable content area. In this edutainment environment, educators will play these roles:

1. **Motivator:** The educator as a motivator is one of the main factors that can contribute towards a different style of learning. The environment can be used to focus the student's attention on what needs to be learned. Hence, the educator should have an idea or incentive to motivate the student to learn.
2. **Content structurer (integrator/reformulator):** The best-organized material makes the information meaningful to the students. One method of organization includes relating new tasks to those that they have already known. Other ways to relay meaning is to determine whether the student understands the final outcome desired and instruct them to compare and contrast ideas. Educators should focus on the creation of the content structure so that they can tailor towards the goal, which should be realistic towards the student's readiness or progress towards the goal.
3. **Debriefer:** Educators should help students reflect on what is being learned, which forms part of the learning process. In this part, the questions of 'how do you accomplish this?', 'what are the steps to get into the next level?', and so on will have not be answered by them. They will act more of a facilitator than purveyor of knowledge.
4. **Tutor (individualiser, steerer, selector, adjuster, guide, facilitator):** An educator should act as a tutor, to be able to customise and individualise learning to each student's diverse learning style. In this new style of learning, it is one of the great opportunities offered through the combination of education and entertainment technology.
5. **Producer/designer:** By having such a tool for game creation, educators can be producers or designers. This is the most crucial role for an educator and an important aspect in preparing today's educators. It is contended that they have the ability of being a motivator, content structurer, debriefer and tutor, but to be a producer or designer, they must be trained and provided with a tool.

Hence, the design framework for edutainment environment can be illustrated as in Figure 1 (Zarina, 2005).

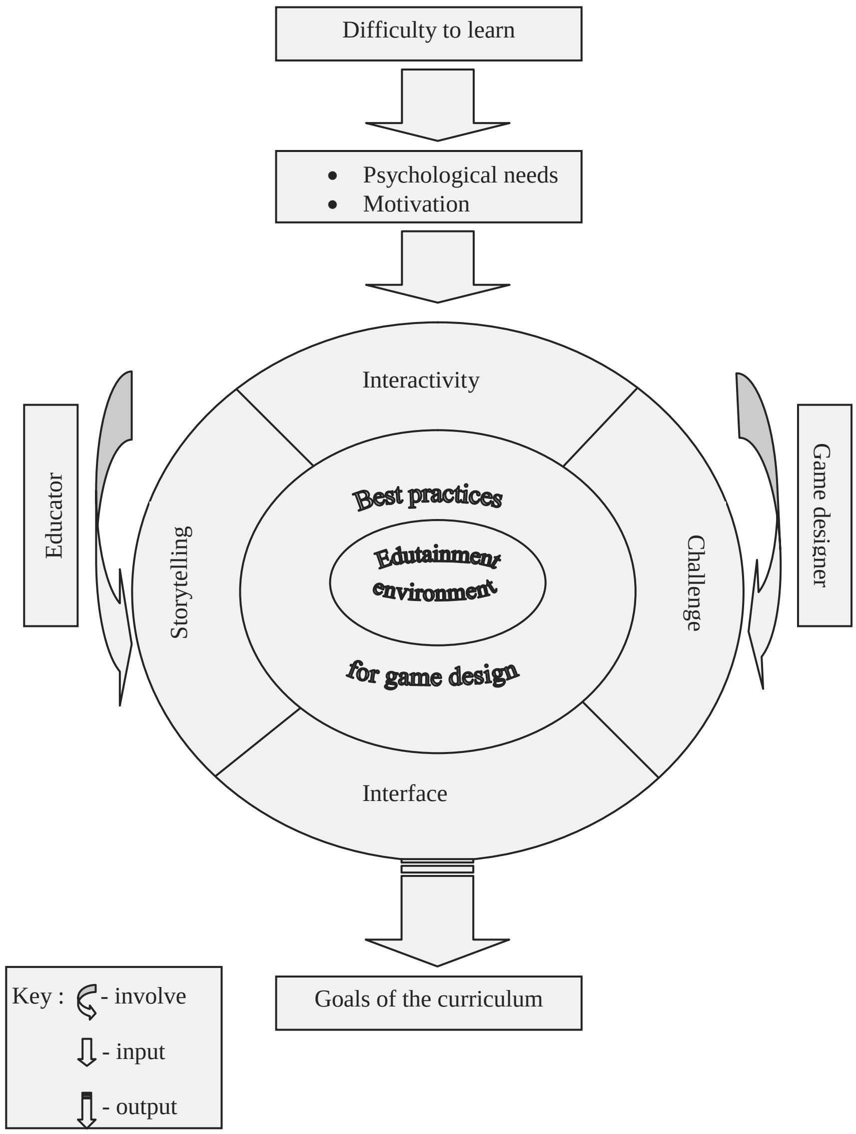
CONCLUSION

There are several potential advantages in the design framework for edutainment environment that has been refined in this research:

1. It addresses the difficulty for the children to learn a subject matter by fulfilling their psychological needs. Hence, it can increase motivation, known as the key towards successful education.
2. The best practices for game design to be addressed by game designers include content or storytelling, interactivity, interface, and challenge. However, within this framework, they need to focus on creating a tool instead of the actual game and therefore need not be concerned of the learning content or storytelling element which they are not familiar with.
3. The educators can acquire the five new roles, namely, motivator, content structurer, debriefer, tutor, and designer (Prensky, 2001) by implementing this framework. This will increase their skills and creativity in an effective edutainment environment.

By implementing this framework, there will be no concern of having to purchase whichever edutainment products might be suitable for the children's learning capacities. It will be more cost effective as well as beneficial to the educational institution at large. Merging technology in education for the cognitive development especially in subjects like mathematics is not a simple task. The implementation of this framework requires a long-term study and takes time to accumulate results. The future works will involve pilot project with the

Figure 1. The design framework for edutainment environment



prototype to be developed and tested on the targeted users.

FUTURE TRENDS

Future work is needed to overcome the limitations of this research and verify the results to address a wider scope of research subjects and settings. Issues on collaborative learning can be investigated thoroughly in future research. It is important to determine whether playing together is better than playing alone. The framework can be enhanced to include this factor if it contributes towards a more effective edutainment environment.

The development of a tool prototype for the implementation for this framework is a direction in future research to test the overall effectiveness on specific issues: to determine which activities promote concept development for different topics, to develop guidelines on how to minimise children's focus on the game activity (gradually shift it towards the subject activity), and to determine the types of interface, interactivity, and challenge that can enhance children's enjoyment of the activity without distracting them from the learning outcome expected from the storytelling of a game. The prototype should also be tested in primary and secondary schools to determine the applicability of this framework as well as to determine a suitable age group for its implementation.

Future research is needed to investigate how to increase the coupling between the game module and the instructional module that is much lacking in existing edutainment products. Research is also needed to investigate how to encourage children to use the instructional module more often without feeling bored or giving up on it.

Although much has been done by researchers in the area of computer-supported cooperative learning, further research of the effect of technology is needed. Most of the studies of cooperative learning on computer tasks emphasize the way the educator can structure cooperative tasks and group compositions to maximise academic and social benefits using existing technology. It is important to investigate whether some of the benefits of cooperative learning may be enhanced by changes in the computer hardware, the software, or the choice of user interfaces. There is also a need for further research in multi-input systems and other shared-screen issues.

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KEY TERMS

Computer Games: Computer games are digital games that are developed for computer such as a personal computer. It also reflects on games that are played online by using a personal computer to interact with other game players on the Internet.

Educational Software: Educational software is the developmental and non-developmental software which are specifically used for education. It also reflects on the technical and also instructional design for developing the courseware or educational application.

Edutainment: Edutainment refers to a combination of the two areas namely education and entertainment whereby the terms 'player' and 'learner' are occasionally treated as the same although player means the game player while learner means the edutainment user.

Edutainment Environment: Edutainment environment refers to the coupling between the game module and the instructional module, but not to leave out the area of computer-supported co-operative work for teaching and learning. Thus, most of the studies of co-operative learning on computer tasks emphasise how the educator can structure co-operative tasks and group compositions to maximise academic and social benefits using existing technology. It also looks at the possibilities of enhancement by changes in the computer hardware, the software, or the choice of user interfaces and the multi-input systems and other shared-screen issues.

Electronic Educational Games: Electronic educational games refers to electronic games that are used for educational purposes and are interchangeably used with the term edutainment. Although these two terms do not actually refer to the same thing, for this research, it is combined based on the factor of motivation. It also involves other means of electronic devices other than computer such as game consoles or video games, mobile devices, etc.

Electronic Games: Electronic games refers to all means of digital games that are developed for various types of digital machines such as computer, handheld, game consoles, mobile phones, Internet or other digital machines.

Framework for Edutainment: Framework for Edutainment is a direction in the research to test the overall effectiveness on specific issues namely to determine which activities promote concept development for different topics, guidelines on how to minimise users' focus on the game activity (gradually shift it towards the subject activity) and to determine the types of interface, interactivity and challenge that can enhance users' enjoyment of the activity without distracting them from the learning outcome expected from the storytelling of a game.

ENDNOTES

1 Head Start is a federal program for preschool children from low-income families. The program is operated by nonprofit organisations in the United States of America. Children who attend Head Start participate in a variety of educational activities. They also receive free medical and dental care, have healthy meals and snacks, and enjoy playing indoors and outdoors in a safe setting. Most children in Head Start are between the ages of three and five.

2 This part of the work has been presented and published in the proceedings of International Conference on New Educational Environments – ICNEE'03, Lucerne, Switzerland entitled "Empirical Study on Implementation of a Framework for Edutainment Environment" and in the proceedings of International Conference on Computers in Education – ICCE2004, Melbourne, Australia entitled "The Implementation of Design Framework for Edutainment Environment: A Case Study in Malaysia."

E-Government Growth Barriers in Sub-Saharan Africa

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INTRODUCTION

E-government, as described by the World Bank, is the use of information and communications technologies (ICT) to transform government by making it more accessible, effective, and accountable to its citizens (InfoDev, 2004). E-government involves the utilization of technologies such as the Internet to improve the services, functions, and processes of governance (Heeks, 1999, 2001, 2002; Moon, 2002). Although, the Internet is vitally important for the process, it has to be pointed out here that e-government is more than establishing a Web server and hosting government sites (Sanchez, Koh, Kappelman, & Prybutok, 2003; Sharma and Gupta, 2003). In fact, Heeks (2001) describes e-government as i-governance or *integrated governance*, a process that permits the integration of both the processing of information by people and the use of communication technologies in achieving the objectives of governance. The United Nations Division for Public Economics and Public Administration and the American Society for Public Administration (UNDPEPA/ASPA) state "E-government is about opportunity…to provide cost effective services to the private sector…to enhance governance through improved access to accurate information and transparent, responsive, and democratic institutions" (UNDPEPA/ASPA, 2003, p. 6).

Furthermore, e-government is indeed an emerging model involving the citizenry and the state in such a way that the importance of citizen's input in policy formulation and implementation is recognized and valued (Breen, 2000). Wimmer and Traunmuller (2001) contend that the main objectives of e-government should include the following: (1) restructuring administrative functions and processes; (2) reducing and overcoming barriers to coordination and cooperation within the public administration; and (3) the monitoring of government performance. Similarly, the World Bank (InfoDev, 2004) provides a guideline for developing countries with respect to developing e-government. The body asserts that e-government initiatives should target the following:

- Promote civic engagement by enabling the public to interact with government officials and vice versa
- Promote accountable and transparent governments in which the opportunities for corruption are reduced
- Provide a greater access to government information and activities
- Provide development opportunities, especially the sorts that benefit rural and traditionally underserved communities

Advances in ICT over the past decade have accelerated the diffusion of e-government practices in both developed countries and developing countries (Accenture, 2004; InfoDev, 2004). According to the UNPAN (2005) e-government survey, almost all the governments in the world have embraced one form of e-government or another. It goes without saying that many developed countries have incorporated sophisticated services while other nations are just beginning to understand the importance of such a concept in governance (Accenture, 2004). A majority of countries in Africa fall into the latter category. The limited use of ICT in governance in the disadvantaged regions of the world, including Sub-Saharan Africa—this is the region of Africa excluding the northern part of the continent and the Republic of South Africa—has resulted in generally low rankings on the various indices used to compare e-government readiness across nations and regions (UNPAN, 2005). Indeed, the e-government readiness score for the whole of Africa is 0.253, which is below the world's average of 0.415.

Surprisingly, a report states that "the most innovative uses of the Internet in governance are appearing in the developing world" (InfoDev, 2004, p. 8) despite the prevalence of chronic limiting factors in the developing parts of the world including Africa. Another piece of good news is that many countries in Sub-Saharan Africa have started to make efforts to "catch-up" in terms of adopting and using ICT products (Kaaya, 2003; Lal, 1999; Thomas, LeBlanc, Mbarika, & Meso, 2004; UNECA, 2004; UNPAN, 2005). This wind of change may be attributable to the fact that many African governments are beginning to accept the notion that ICT use in general and for governance in particular could hasten socioeconomic and political development (see, Heeks, 2002; Ifinedo, 2005a, 2005b; Thomas et al., 2004). That said, while development reports and research studies have discussed the poor showings of Sub-Saharan African region with regard to e-government readiness, the study of the literature indicates that few commentators have written about the sorts of factors negating the growth of e-government initiatives in the region. This article aims at contributing to the literature in that respect as it develops a conceptual model that highlights the barriers to the growth of e-government in Sub-Saharan Africa. Nigeria, the most populous country in the region was chosen for illustration purposes. Additionally, Ifinedo (2005a, 2005b) and Ifinedo and Uwadia (2005) have discussed e-government progress in the country, and this present work serves to complement these previous efforts. Next, the conceptual framework is presented.

THE BARRIERS TO THE GROWTH OF E-GOVERNMENT INITIATIVES

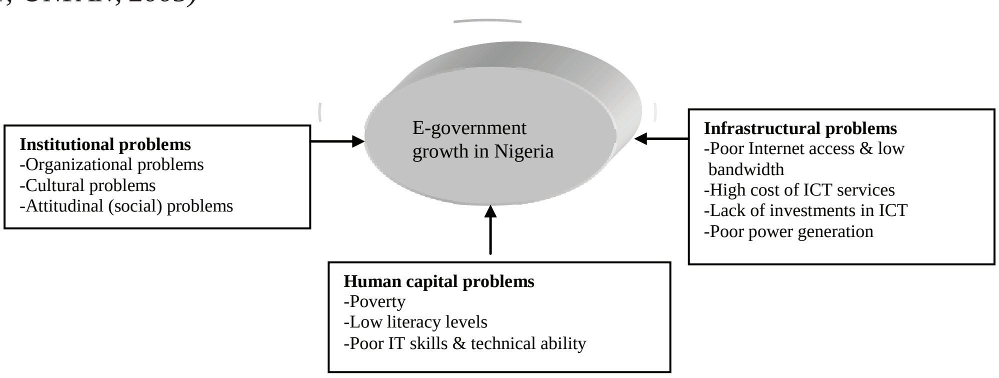
The conceptual model illustrated by Figure 1 will guide the discourse regarding the barriers to e-government growth in Sub-Saharan Africa. As briefly noted earlier, this chapter considers perspectives from Nigeria. The framework draws from developmental reports of notable bodies such as the G8 DOT Force (2001), UN ICT Task Force (2004), and UNPAN (2005) that have described the barriers to ICT use in developing societies. These foregoing reports identified three broad categories of factors believed to be hampering the efforts of developing societies in making the most of ICT products for social and economic development. The three categories include the following: (1) infrastructural problems, that is, poor information and telecommunication technologies facilities; (2) institutional problems; and (3) human capital problems. For example, UNPAN (2005) listed poverty, low levels of literacy, lack of adequate infrastructure, high cost of ICT services, lack of investments, and poor institutional structures as some of the challenges for developing countries with respect to ICT use and adoption.

Institutional Problems

Organizational Problems

Effective communication and organizational skills are needed to maintain the vision, values, and aspirations of all stakeholders in an e-government initiative (Sharma & Gupta, 2003). This calls the role of government functionaries in Nigeria into question. Would they be sincere in implementing and managing the values of e-government properly? Do they understand the prerequisites for e-government? Will these functionaries not use ICTs for their own ends? The reality is that government agencies and officials in developing

Figure 1. The conceptual model of the barriers facing e-government growth in Nigeria (Adapted from: G8 DOT Force, 2001; UNPAN, 2005)



countries might perceive e-government as a potential threat to their power, and as a consequence may show reluctance in promoting the objectives of e-government (Heeks, 2002; Kaaya, 2003; Sanchez et al., 2003). Heeks (2002) recounts examples where e-government efforts in Africa totally or partially failed due to "people" factors. For example, due to a lack of organizational skills and/or commitment, Nigeria has previously witnessed failures with committees mandated with developing and managing its national ICT polices; in fact, no sooner was a body formed was it disbanded for another (Ifinedo, 2005a). Prior to NITDA (Nigerian IT Development Agency), the current body that administers the national ICT policy and e-government projects in Nigeria (NITDA, 2001); there was Central Computer Committee (CCC) before it. Even after the formation of NITDA in 2001, the former head of the body openly expressed disappointment in 2003 when he asked why several keys issues in the policy statement have not been addressed (Ajayi, 2003b). In brief, one could argue that establishing e-government and related initiatives in a developing society such as Nigeria will continue to be challenging given the prevailing lack of organizational vision and commitment.

Cultural and Attitudinal Problems

West (2004) notes that individual behavior and cultural norms may impact upon the way technology is used by citizens and policy makers of a country. In fact, Ojo (1996) asserts that ICT and similar products will thrive better in cultures that have a mechanistic view of the world, unlike in Africa where informality thrives. The impact of culture on ICT adoption in the developing countries has been a topic of interest in information systems (IS) literature (e.g., Anandarajan, Igbaria, & Anakwe, 2002; Straub, Loch, & Hill, 2001). Findings from Straub et al. (2001) study indicates that sociocultural factors are vitally important for the diffusion of ICT-enabled projects in developing societies. Further, the attitude or culture of self-motivation among government functionaries is rife in Nigeria (Ifidon, 1996; Ojo, 1996). There is a tendency to over-politicize decision-making, indulge in shoddy practices, and institute complex bureaucratic procedures in order to gain personal advantages. In the context of developing societies in Sub-Saharan African, it can be argued that those with an interest to protect may choose to downplay the benefits of e-government or simply sabotage it. Evidence from Nigeria seems to affirm this proposition (see, e.g., Ifidon, 1996; Ifinedo & Uwadia, 2005; Ojo, 1996).

Human Capital Problems

Nigeria is poor and indebted (CIA: World Factbook, 2005; World Bank Group, 2004). The economic situation is dire for both the country and its population. The Nigerian government does not have the capability to adopt and implement sophisticated e-government services (even the basic ones) partly due to inadequate resources that often have to compete with other pressing issues like reducing poverty among the population and the foreign debts servicing (Ogwumike, 2002). Further, illiteracy is rife in Nigeria—it is at about 40% (Ifinedo, 2005b; Oyebisi & Agboola, 2003; CIA: World Factbook, 2005), and secondary education enrolment is low (Dutta, Lanvin, & Paua, 2003; Ifinedo, 2005b). In addition to the generally low literacy level in the country, Nigeria also lacks qualified IT professionals (Dutta et al., 2003; Odedra et al., 1993; Ojo, 1996). Needless to say that these inadequacies hamper the growth of e-government as skilled hands needed to develop such services may not be readily available. Nigerian universities do not produce sufficient skilled IS professionals to match its current ICT needs (Oyebisi & Agboola, 2003; Ifinedo, 2005a, 2005b). Oyebisi and Agboola (2003) assert that the highest enrolment in the University for Science and Technology in Nigeria between 1991 and 1998 per 1000 inhabitants was 0.31, with only 0.05 per 1000 students earning a postgraduate degree during the same period. It is difficult to see how e-government can thrive under such unfavorable conditions.

Infrastructural and Technical Constraints

As with the rest of Sub-Saharan Africa, Nigeria's Internet access is poor (ITU 2005; Internet World Stats, 2004). There are about 3 million Internet users in a country of 140 million inhabitants—this is less than 1% of the population (CIA: World Factbook, 2005). Access to the Internet is crucial for e-government services. In the same vein, insufficient bandwidth is yet another problem. Only recently did a few countries in Africa procure bandwidths greater than 10 million bps (Anonymous, 2002). Previously, many countries in Africa had bandwidths between 64,000 bps and 256,000 bits per second (bps) due to high international tariffs and lack of circuit capacity in the region (Anonymous, 2002; Internet World Stats, 2004). The investments—local and foreign—in such facilities are low on the African continent (Anonymous, 2002; ITU, 2005; Ifinedo, 2005b). The cost of subscribing to a telephone line or owning one is beyond the reach of an average citizen. The same is true with procuring Internet access in Nigeria. Thus, ordinary citizens cannot afford such services (Ajakaye & Kanu, 2004; Dutta et al., 2003). The cost of a PC in Nigeria is six times the monthly wage of an average worker. Computers and Internet access are two vital facilities required for any e-government engagements, but when such facilities are lacking, as is the case in Nigeria, it remains to be seen how the populace can benefit from such initiatives.

Under the military dictatorships in Nigeria, the country witnessed poor inflow of investments. The telecoms sector was adversely affected by that situation (Ndukwe, 2005), and was worsened because many states in Africa, including Nigeria, often provide telephone services to their citizens (Ifinedo, 2005). As would be expected, inefficiency and poor quality were often associated with such services. Another major infrastructural constraint in Nigeria is inadequate power generation and supply in the country (CIA: World Factbook, 2005). Constant supply of power is required to operate effective e-government services; it is sad to note that such is not the case in Nigeria where there are endless power outages. Government functionaries in the country are now coming to the realization that any meaningful e-government service will need a steady supply of electric power (Ifinedo and Uwadia, 2005).

CONCLUSION AND FUTURE STUDY

This chapter has attempted to discuss the barriers to the growth of e-government in Sub-Saharan Africa by focusing on the challenges in one country in the region: Nigeria. Towards that end, a conceptual model that draws from the related literature was developed to guide the discourse. The main challenges facing the growth of e-government in Nigeria apparently are related to socioeconomic and cultural inadequacies. Examples of those include poor organizational skills, poor infrastructural facilities, and poor or unavailable human capital resources. There is a need for concerted efforts to be developed to address some of the barriers discussed herein. The Nigerian government as well as others in comparable countries in the region could pay more attention to the highlighted problems in order to improve their e-government readiness scores. Owing to the similarity in the socioeconomic and cultural conditions in many of the Sub-Saharan African countries, it is likely that the same sorts of problems seen in Nigeria may be hampering the growth of e-government services in these comparable countries (Ifinedo, 2005b).

It is important to mention that there are ongoing efforts to redress some of the barriers discussed herein. For example, there is a partnership formed between the Nigerian government and private stakeholders to tackle the barriers to e-government in the country (Ifinedo, 2005a). Furthermore, it appears the leadership in Nigeria is turning a new leaf as it now realizes that more attention is needed to grow e-government services in the country (Ifinedo, 2005a; Ifinedo and Uwadia, 2005). The importance of e-government for developing societies in Sub-Saharan Africa cannot be overemphasized (InfoDev, 2003). Ifinedo (2005b) cites Late F. Houphouet-Boigny (the long time President of Ivory Coast) where he commented that "after, having missed the industrial revolution, Africa should not once more miss the computer revolution." He continues: "…countries that neglect this domain in their development process are increasingly widening the gap between themselves and the developed countries, who will find in this a new reason to exercise more monopoly over power." Future study on e-government in Nigeria and comparable countries may add to this present work by investigating how commitments from state leadership could enhance e-government initiatives. Researchers could examine the perceptions of Nigerians vis-à-vis e-government services. To sum, insights from this chapter could serve as a base for future works.

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KEY TERMS

E-Government: This is the use of ICT to transform government by making it more accessible, effective, and accountable to its citizenry.

E-Government Readiness Index: This is an index for comparing e-government initiatives around the world.

Human Capital Problems: These refer to barriers including poor financial and technological resources that may negatively impact the spread of e-government projects in a country.

Information and Communications Technology (ICT): These include technological products such as telephones, computers, the Internet, and so forth, which are used to convert, store, protect, process, transmit, and retrieve information.

Infrastructural Problems: These include challenges such as the lack of relevant infrastructure e.g. the Internet, electric power generation needed for e-government initiatives in a country.

Institutional Problems: These refer to organizational and cultural barriers that may negatively impact the growth of e-government services in a country.

Integrated Governance (I-Governance): This refers to the integration of both the processing of information by people and the use of ICT in achieving the objectives of governance.

Internet: This is a global network of interconnected computers using multiple protocols.

Sub-Saharan Africa: This is the region of Africa excluding the northern part of the continent and the Republic of South Africa. Examples of countries in the region include Nigeria, Senegal, Togo, and Kenya.

E-Knowledge

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INTRODUCTION

Change is driving the new millennium along many paths. There is one particular place where the change is especially deep, and that is the path in which knowledge is heading. However, this is not always perceivable and it takes an act of detachment to appreciate it. The same is happening with the main cause of that change, which is technology: it is so much a part of our daily life, that we are no longer aware of it.

Contemporary *digital* media and *digital* technologies, that is, the most innovating front of ICT, have a characteristic: they reciprocally function as triggers, giving way to sudden waves of adoption, which in turn start others, all much more rapid and frequent than in the past. We are flooded, often unwillingly, by storms of technological stimuli: even though we may not be conscious of them, the result is an empowerment of our faculties of action, communication and cognition.

The term "e-knowledge" has been coined, as several others of similar structure, to catch, via the "e-" extension (*electronic*), the new shape of knowledge which is peculiar of a deeply technology-driven world. In such a world, *technes* (re. technology) is no longer "the art of making" and it becomes the "art of knowing".

The impact of technology on knowledge is remarkable. Diana Laurillard (Head of the e-Learning Strategy Unit, U.K. Government) notes in a book that we shall discuss, that there is a case for "*a debate about epistemology—when the knowledge technologies change so radically, they change not just what we know, but how we come to know it*" (Laurillard, 2003).

E-knowledge is knowledge made to rise through technology-intensive processes, marks a break from tradition. It is no more a matter of formal learning, coded facts pulled from the tree of a carefully compiled Dalembertian encyclopedia. It develops a different perspective, inspired by constructivism, where the classical hierarchy—knowledge owner above knowledge recipient—is undone, allowing the emergence of a protagonist that is no longer the *sapient*, but the *knower*.

Knowledge management schools, for a decade at least, have provided us with enlightenment about the nature of knowledge, showing the virtuous methods that enterprises should adopt to transform human capital into corporate advantages and progress. But e-knowledge has an ampler reach than the business domain, which is the realm where the influent scholars of the past decade had placed it (Nonaka, Toyama, & Konno, 2001). It concerns the "social" individual in its entirety, in any environment and belonging to any class. The individual is a subject at the center of actions that metabolizes into knowledge the mass of information flowing by.

HISTORY

The term "e-knowledge" is a neologism that is making inroads into our culture. In the same way as the coinage of certain scientific terms in the life sciences had the effect of determining the direction of research in that field (Fox Keller, 1996), so it has been for this word. Its creation can be seen as a "performative" act, where the word is not valued for its descriptiveness, but for its effectiveness. It is in fact succeeding in modeling our current and future vision of knowledge.

Those who coined the term are a group of experts, Donald Norris, Jon Mason, and Paul Lefrere, authors of the book *Transforming e-Knowledge, A Revolution in the Sharing of Knowledge* (Norris, Mason, & Lefrere, 2003a). A set of well-known and respected figures in the fields of education and strategy (SCUP, 2006), they (NM&L for short), will be our main reference. We will complement their thoughts with those of other authors, speaking to us from diverse domains, because the issue of knowledge crosses all disciplines.

There is a particular worth in NM&L's writings. They are the fruit of collective thought, the result of a consultation among many international experts with different skills. These people met and worked to find an answer to a crucial issue:

How individuals and organizations needed dramatically to enhance their capacity to acquire, assimilate, and share knowledge, given the constant pressure of disruptive change. (Norris, Mason, Robson, Lefrere, & Collier, 2003b, p. 26)

NM&L's kind of answer is a very valuable one: a programmatic document, with strong propositions. Beyond the wealth of facts, references and intuitions, the answer we find in *Transforming e-Knowledge* is: "use the new technologies, they are essential in order to innovate and share." There is also the incitement to demystify the complexity of knowledge and to overcome the "provincialism" of academic knowledge (aggressively defined "*a 'cottage industry', the purview of isolated craftspeople and professional guilds*").

NM&L have a sharp perception of the role of technology:

Mobile, ambient technology is changing the dynamics of how we will live, work, and learn. Such technology environments will revolutionize everything about the "knowledge experience": place, use of time, nature of interfaces, intensity of engagement, reliance on just-in-time knowledge and agents, ability to multi-task, and the amenity of the knowledge experience. These new experiences will shape behaviors, practices, and social groupings for knowledge sharing. (Norris et al., 2003a, p. 1)

APPROACHING E-KNOWLEDGE

How does knowledge get to us? To address this question, open since the Sophists' time, we shall answer here but with an essential schema.

In line with NM&L's thinking, with Brown and Duguid's elegant and profound work "*The social life of information*" (Brown & Duguid, 2003) and with strategist Shedroff's key essays (Shedroff, 1994), we shall put knowledge and e-knowledge next to each other and show the transition from one concept to the other.

Knowledge vs. E-Knowledge

Using a conceptual schema we can think of knowledge as an intermediate ring, or node, in a representation of a *value chain,* that involves other concepts:

data → information → *knowledge* → wisdom

Data, large unshaped heaps of items of different sorts, are the resource that we use to communicate. However, as Shedroff remarks (ibid., p. 3), data are "boring" because they have no consequentiality and, if "left to themselves", have neither interest nor value.

Data to which an organization has been applied, or which are the object of a presentation, or in which a pattern has been identified, acquire meaning and become *information*.

We arrive at knowledge though experience, social interaction and with the help of our intuition. Knowledge is not transmitted (it is information that is transmitted). Applying a constructivist paradigm, then, "*Knowledge is information that is presented within a particular context, yielding insight on application in that context, by members of a community*" (Norris et al., 2003a, p. 2).

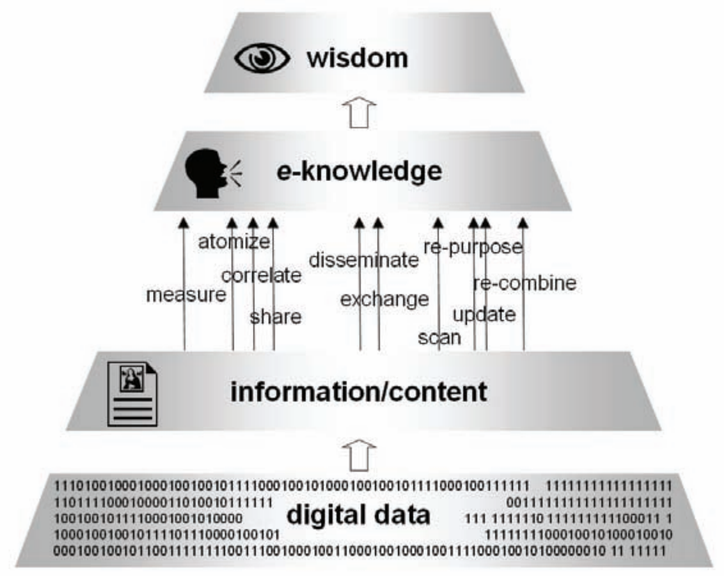
Wisdom, at the far right in our representation, can be interpreted as a sublimation of knowledge, a kind of metaknowledge (Shedroff, 1994), and a deep personal insight. It cannot be shared and one reaches it substantially only though oneself.

At the moment when, metaphorically, the *digital revolution* strikes, there is an effect (see Figure 1) that starts from the data side: data become "digitalized" and the effect propagates forward. Information now takes on a more meaningful connotation, becoming "content", with reference to the many multimedia formats now possible. The "passage" from "information/content" to what we now label "e-knowledge" becomes enriched by numerous paths and acquires a great flexibility. The entire knowledge ecosystem (thus we call the set of balancing entities and intervening paths in the illustration) becomes animated with reactions and counteractions.

Many of the action-verbs in the illustration are common, but their newness and special power in this context should not go unnoticed, for instance:

- **Correlate:** It is the principle on which are built those intriguing visual representations called *knowledge maps* (see the one at Netzspannung.org, 2005); it is the foundation of the most advanced *digital repositories*;
- **Share:** It is the fundamental equation ruling the Web and the world of virtual communities;
- **Scan:** The mechanism at the heart of search engines, irreplaceable prostheses for our memory;

Figure 1. The knowledge ecosystem



- **Atomize, repurpose, recombine:** Some of the main activities performed when implementing technology-enhanced learning.

Technologies Supporting E-Knowledge

The dynamic features of e-knowledge are the result of many technologies, but some of them, that we can name "knowledge technologies", are particularly powerful, even disruptive, because they overcome old barriers and open totally unforeseen possibilities. Some of the fields where the impact is greatest are:

Education

There is a fundamental relationship between knowledge and learning, therefore in this sector technology-enhanced learning is developing quickly, with:

- New ways for packaging digital content, based on Learning Objects theory and practice (Horton & Horton, 2003);
- A new generation of systems that combine sophisticated software and hardware: LCMSs (learning and content management systems), collaboration platforms, VLEs (virtual learning environments) (Dillembourg, 2000);
- New concepts and methodologies for the dissemination of learning content, promoted by international bodies: IMS (instructional management systems project); ADL (advance distributed learning initiative);
- New disciplines derived from pedagogy, information technology and HCI: instructional design, interaction design.

Librarianship and Architecture of Information

The development of a new science concerning metadata (structured data about data) is giving an extraordinary contribution to knowledge intelligence. Although it presents itself as a niche for specialized scholars, metadata science is a fundamental building block of the knowledge economy. It supports many popular and widely used applications: not only e-learning (Fini & Vanni, 2004), but also all the range of digital repositories, real arks of knowledge accessible without restrictions and at no cost, as *DSpace* (Smith, Barton, Bass, Branschofsky, McClellan, Stuve, 2003). Metadata are the core of great variety of "online library systems", from one "personal library system" such as MIT's *Uplib* (Janssen & Popat, 2003), up to one of the most hyperbolic knowledge-oriented tasks of our time, the

Library Project, (by books.google.com, an "*effort to make the knowledge contained in library books discoverable by everyone*"). Furthermore, the automated sharing of metadata across applications is an important part of realizing the goal of the *Semantic Web*, another renowned scientific effort of our times.

Mobility

Wireless communications tremendously improve access to information, by enabling it for the mobile user. Local wireless services (wi-fi and successors) have enhanced it to an ever-greater degree. The possibility for anytime-anywhere informal exchanges by people in dynamic contexts, the flexibility of the new, no longer static collaboration systems, the advent of location-based services and locative media, demonstrate that wireless communications are an extremely powerful enabler of knowledge. The *Book of Visions* of the Wireless World Research Forum (Tafazolli, 2004) tells us what will happen in the future.

BEYOND E-KNOWLEDGE

Since its launch, the role of e-knowledge as a "power word" has been clear. We find it, for example, in project names as "eTieto" (eknowledge in Finnish) dealing with the "eco-information society" (Heinonen, 2006), or in research papers, like a thesis about knowledge networks (Raghavan, 2004). However, the "*constant pressure of disruptive change*" did not stop in 2003, when NM&L took notice of it. It is now the time to make the "e-" disappear, now that the concept of knowledge indissolubly implies the presence of the "ICT ingredient", without which dissemination and sharing would immediately stop.

Thus, as a conclusion drawn by those very authors, beyond e-knowledge, there is, just "knowledge".

Nevertheless, the attempt to record and give an interpretation to something that is either a change, or a jump, or a "paradigm shift" felt by all, continues. Some propose "knowledge 2.0", along with a popular naming fad (Stumpel, 2006). People are bedazzled by the speed and power of reach afforded by modern media channels and fall perhaps into a trap, to mistake information for knowledge. But to unravel what is inside the new and future modes of knowledge, one should not look only at the sources, which are abundant, or at the media, which are alluring, but at the target, which is the mind of man. We surmise that a transformation is in progress precisely there, driven by the effort to manage the great flow of messages that the dense "information aura" surrounding us, is sending.

YET MORE CHANGE

We do not believe that ICTs, assessed over the entirety of the human population, can be a barrier to knowledge, as suggested by the dystopic view of a *digital divide* that would be increasing with time.

A good sign is the democratization of some of the main fruits of the technological progress: the steady worldwide growth of cellular devices, PCs and Internet links, which are vital tools in support of knowledge. Their adoption takes place either autonomously or thanks to courageous undertakings, like Nicolas Negroponte's "education project" *OLPC* (One Laptop Per Child) (Figure 2). Founded at MIT, an open shrine of technical knowledge, the program will benefit a huge number of "have-nots" of the digital world (OLPC, 2006).

Large-Scale and Small-Scale Change

There is a high risk of proposing the abundance of digital information and communication as the exclusive means to realize knowledge, substituting them to the variegated direct experience of the world. It is what Brown and Duguid, in their cited book, flag as dangerous "information fetishism" (Brown & Duguid, 2003).

Figure 2. The OLPC device (concept image) (Source Design Continuum (OLPC, 2006) licensed under CCA 2.5)

After e-knowledge and knowledge 2.0, we should ask ourselves what "yet more change" could mean in the domain of knowledge. There are two streams of technological and conceptual innovation that we choose for an answer: *ambient intelligence* and *bio-engineering*.

Ambient Intelligence (AmI)

Named a "true vision" by one the founders (Aarts & Encarnação, 2006), on the basis, today, of numerous fully developed application fields, AmI "*provides a paradigm for user-centric computing*", where human beings are placed at the center of future developments of the knowledge-based society.

AmI, among other directions, proposes the redefinition of the environments where knowledge is generated (work spaces and learning spaces) introducing harmonized multimedia channels, high-immediacy communication tools and intelligent software agents. The richness of such multisensorial experiences is hard to convey in words, but not in images. A clever webcast by a major wireless telecom operator, presenting its "futures", can be taken as a proof (Vodafone Future Site, 2006). In this video one can verify the attractiveness of applying sonic technology, positioning services, electronic paper, visualization devices, microsensors, all siding with wireless networking, to the everyday life of working people and families. AmI will effect large-scale changes in the "knowledge experience" of people.

Bioengineering

This area would need a better name than just "bioengineering". What we address here is at the frontier of artificial intelligence, machine learning, neuroprosthetics, and robotics, with (human) bioengineering. It could be dismissed as ground just for futurists, but although its effects may be initially small, namely benefiting individuals with certain reduced capabilities, its underlying rationale has a wide bearing.

When we focus on the relation mind/brain ↔ knowledge as supported by technology, we cannot avoid noticing that humans become more and more technologized and technologies (i.e., machines) become more and more humanized. It is useful to put side by side the recent results of applying neuroprosthetics to a quadriplegic—a individual who can now open e-mail with the power of thought (MIT Tech Review, 2006)—with the vision of a renowned scientist, inventor and thinker, Ray Kurzweil, who presents in an unbelievable book the astounding effects on intelligence of merging biology with future computing (Kurzweil, 2005). We would find that reality and vision are well aligned.

If the mind/brain term of the aforementioned relation changes then the other term, that is, the whole set of concepts we hold around the notion of knowledge, will change, but in some yet unknown way.

"*The nature of knowledge is that it makes itself obsolete*" says renowned economist Drucker (2000).

Although we say we live in a Knowledge Society, we keep struggling with an elusive notion. It will be good to keep in mind that in our times the "shelf life" of knowledge is very short, unless we renovate it continuously by blending it and sharing it with our fellow humans (ready to do it with machines).

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KEY TERMS

Constructivism: Is at the same time a theory of knowledge, a theory of learning and an educational methodology. It is, therefore, an ample space for debate and controversy. In our context a constructivist approach to knowledge means that we ourselves build an interpretation of the reality surrounding us, through experience. Rather than a knowledge transfer from source to sink, we gain knowledge by an active engagement in its construction, by giving to and taking from others.

Digital Revolution: An expression used to denote the extraordinary transition in media, communications, devices (and ultimately economics and society), from an analogue form (i.e., continuous, linear signals representing information) to a form expressed in discrete digits (actually: bits). This started in the early 1980s.

Learning and Content Management System (LCMS): Fundamental computer systems for implementing technology-enhanced learning, often called a "platform". It involves many digital components and tools of a very specific nature. It is exploited both by the end-users (learners, usually in distant locations) and by the authors, teachers and tutors who prepare and manage educational content and curricula (courseware).

Location-Based Services (LBSs): A new generation of telematic services based on the capabilities of wireless networks, or of the global positioning system (GPS), and mobile communication devices (or other radiofrequency sensitive devices). LBSs are able to detect and react to the (geo)location of the user and accordingly trigger a service of some kind.

Virtual Learning Environment (VLE): Is often used in lieu of LCMS. However, the term VLE has a wider connotation than just a single "platform". This interpretation of VLE says that the virtuality of the learning environment is constituted by a combination of tools with different, though complementary, purposes (e.g. one LCMS plus one project development platform plus one digital repository at a central site, plus a set of knowledge management tools at the user's workstation). In parallel, also a set of different educational and management human skills have to coexist and harmonize in a VLE.

E-Learning Function Integration with Corona 2

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INTRODUCTION

The aim of the Corona project, which was launched in 2003 in the context of methodological-technological research on the subject of e-learning carried out in collaboration with CARID ("Centro di Ateneo per la Ricerca, l'Innovazione Didattica e l'Istruzione a Distanza", the research center of the University of Ferrara which studies e-learning methods and techonologies and applies them in real learning contexts) and the Omniacom Consortium, is to facilitate the integration of functional modules (synchronous, such as chat rooms and virtual classrooms, and asynchronous such as the production and provision of Learning Objects, forums, assessment and tracking tools), originating from different development environments, in a single online interactive environment.

Possible Choices for an E-Learning Platform

The project commences with an analysis of a situation common to training organizations aiming to provide e-learning courses: such organizations inevitably come up against the problem of what software tools to choose in order to support online interaction between content experts, tutors, and students.

There are three possible choices: acquisition of a commercial platform, implementation of an open-source platform, or proprietary development.

The first choice enables the purchaser to select from a wide range of products that are important as regards both quantity and quality: the market of this sector, far from being monopolized by the leading software houses, actually offers dozens of well-consolidated solutions.

Identifying the best product for the purchaser's goals and requirements is not a simple task, inasmuch as the enterprises that produce and provide training often have organizational peculiarities which are not easy to match up with the internal structure of platforms designed with general application criteria: the same type of learning proposal, if characterized by complex forms of modularity can come up against obstacles in the platform's standardized management.

The second choice differs from the first mainly as regards cost, not linked to the purchase of the licence but deriving from the need to have qualified computer science engineers for the installation, configuration and, even more important, adaptation of the product to specific requirements, and this entails a considerable investment in terms of time and resources.

The third choice obviously allows for maximum freedom and flexibility of development as well as extensive adaptation to already existing organisational structures, but requires the availability of a technical staff with the capacities to satisfy, by means of programming tools, the function, and interaction requirements desired by the methodological research and development department.

Concept of Interoperability

A further aspect to be carefully considered in the context of the suggested hypotheses is the degree of platform interoperability, that is, the capacity of the platform to implement content modules developed in different environments: this capacity does not, obviously, refer to the banal possibility to download such modules or to use them in stream by means of standard plug-ins, but rather the possibility to implement software procedures that support the tracking of user activities.

In conclusion, the limitations of these three possibilities are such as to render problematic a definitive judgment regarding the best choice to make in order to ensure the efficiency, efficacy, and cost-effectiveness of the results, even in relation to individual situations: from this panorama, the objective difficulty in embarking on such initiatives experienced by institutions involved in online learning methodological and technological research clearly emerges.

E

CORONA PROJECT

In an attempt to tackle the entire issue and identify possible solutions aiming at overcoming the operational and economic limitations posed by the various hypotheses, it is important to consider two fundamental aspects: the need to interact with preexisting databases and software environments and the need to select, customize or construct *ex novo* interaction functions able to support the teaching methods adopted.

In the light of the previous, within the context of the "Corona" project a thin slice of software in Java (the standard Web language, extremely high performing and portable) and PHP (language extremely widespread in online applications, distinguished by its user friendliness, and portability across all main Web-servers) aimed at enabling dual integration with the organisation's database (in which the data relative to the figures involved in the learning process, course areas, and access levels may be found) and with externally developed functions.

The reason for the interest in this project should not be sought exclusively in factors such as flexibility and freedom of choice (indeed, it is important to emphasise that composition of a methodologically consistent, efficient, and high quality environment is a complex activity which is not to be confused with the indiscriminate aggregation of software objects), but mainly in the possibility to improve, complete, and customize, on the basis of the various requirements, the interactive structure on which the online learning environment is based: not wishing, of course, to diminish the primary importance of the strategic design underlying every e-learning environment and platform.

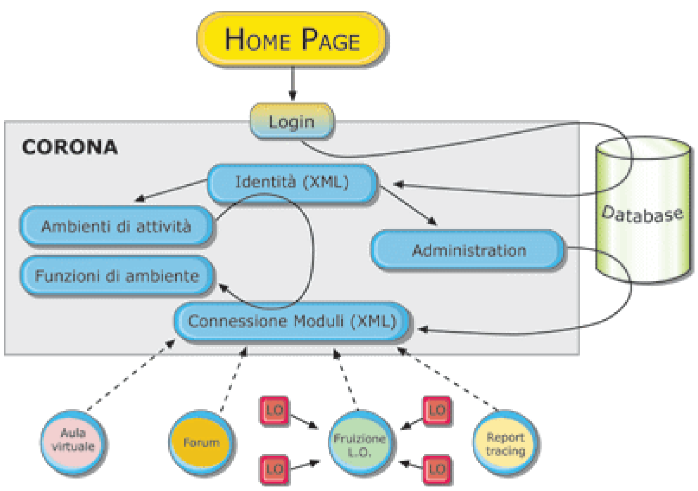
The Beginning

The first version of Corona, which was developed and tested between 2003 and 2005, effectively demonstrated the possibility of developing functional modules that connect easily to the login and integration layer which composes the core of Corona, and similarly the possibility to adapt modules originating from university research, the development of open-source environments and commercial platforms to it.

The focus of Corona is the standardization of the method for transferring data and information between the organization's database and the individual functional modules, for which self-consistency is required (or rather, encapsulation, a fundamental feature of software objects, which may be defined as being the capacity to administer its own functions using only the data and methods existing within itself and the parameters included in the launching instructions), and to which the data relative to the learning context and to the user identified by means of a parameter containing the link to a file in XML format is sent (the following figure summarizes the operational diagram).

In requiring self-consistency of the modules, the first implementation of Corona, does not solve the problem linked to the need—frequent in e-learning environments—to transfer data between various functions (just

Figure 1. Scheme of Corona first version



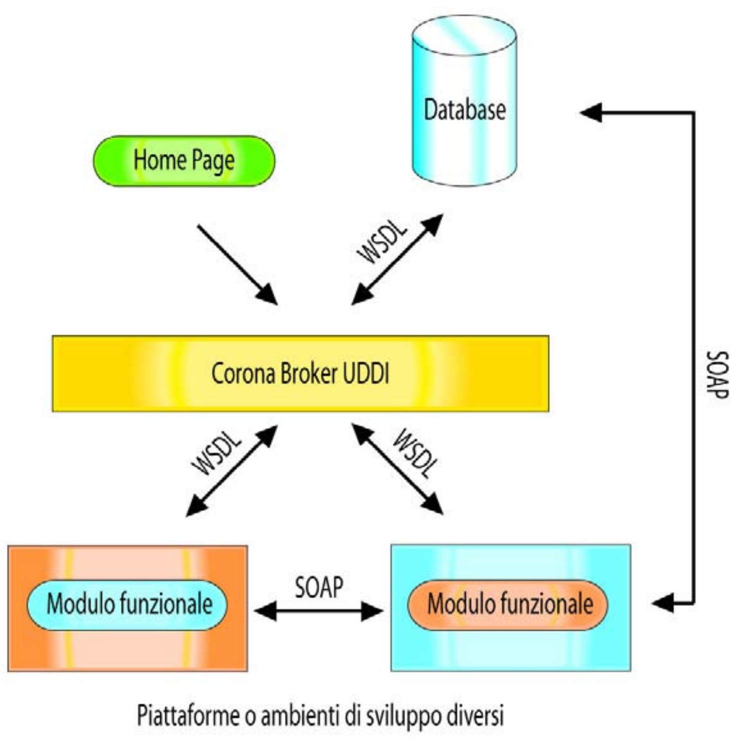
think of the tracking report function, which requires information originating from all the other functions). This problem, or rather the solution outlined for it, characterizes the development from Corona to Corona 2, and falls perfectly in line with standardization of methods for managing online information flows: the transfer of data between the various functional modules and between the latter and the organization's database actually takes place through the well-known and well-consolidated technology of the Web-Services.

The Second Step

In brief, as illustrated in the next figure, Corona 2 acts like an information broker with regard to the possibilities and capacities of the single modules that it connects (a UDDI—Universal Description, Discovery and Integration—broker, for those who are familiar with the specific Web-Services protocols), receiving notices regarding such possibilities, from the single modules, through messages using the WSDL (Web Services Definition Language) protocol. Thus informed, Corona 2 can receive, still through WSDL messages, the operational requests of the functional modules, that is, requests such as "is there a function in the system that performs this task or that is able to supply this information?" and transmit the reply in WSDL to the requesting module, containing the data necessary for a direct contact between the two functional modules. The two can then interact using a communication method (i.e., question and answer) formulated in the SOAP (Simple Object Access Protocol) protocol.

This method of exchanging data between modules implies that the modules themselves, and the management of the database, implement and utilize WSDL and SOAP standards: such instruments may be used both for the management of data flows within a platform and for the aggregation of modules from different sources in the context of a composite interactive environment, normally based on a platform based on a specific teaching methodology—such as the case of platforms implementing tools geared to support constructive collaboration—but with the capacity also to aggregate, for the operators, modules deriving from specific and customized development activities, or from open-source environments, or from other platforms that render their functions compatible with Web-Services standards, in a structured and largely transparent fashion.

Figure 2. Scheme of Corona second version



CONCLUSION

The Corona 2 environment becomes, therefore, the best tool for managing dialogue and interaction between the functional modules composing the e-learning environment and between these same modules and the organization's database, containing the data relative to users and learning contexts: interaction that does not only permit flexibility in the composition of the technological environment to an extent that renders the term "platform" virtually obsolete, but which is in line with the development trends of the Web, which has identified in the Web-Services and in the protocols on which they are based the distinguishing feature, together with AJAX technology for the partial dynamicism of documents, the fundamental tools for the management of advanced online interaction.

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KEY TERMS

AJAX: Acronym for asynchronous javascript and XML, a Web-based client-server interface which enables the document on the client's browser to request and load data from the server—through a special function in Javascript language—without reloading the entire document in dynamic mode: this option enables the efficacious management of high quality networked interfaces, thereby optimizing information flows.

Interoperability: The possibility of platforms to share functions, particularly those linked to the use of content modules which, in order to be used by the interoperable platforms, must adapt to the use of specific protocols (LOM, AICC, SCORM). The aim of the Corona project is to extend the interoperability of the platforms from the simple use of learning objects to all of the interaction functions.

Platform: Environment for the management of learning interaction which involves, with different roles and access levels, the various figures implicated in the learning process, supports the various synchronous and asynchronous functions of the same, and enables the use of content modules (learning objects).

Web Services: Method of data exchange and functional interfacing between software modules located on the Web, based on the sharing of protocols for the signalling of the functional features of each module, for their research and remote use, and for the management of incoming and outgoing data flows from the modules.

Does E-Learning Improve the Communication Among Students and Lecturers?

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INTRODUCTION

This article reports on a survey that investigates the role of e-learning in improving the communication in learning environments. The results are drawn from the analysis of data collected from a sample of 420 university students in Greece. The study focuses on the contribution of e-learning to facilitating the communication among fellow students and the communication among lecturers and students. The results of this article are useful for both practitioners and academics.

Internet technologies are spread across almost all aspects of modern life in business, entertainment, education, and learning. Students in developed countries are already not only computer literate, but also they are becoming the drivers of change for the future economy. E-learning services and courses are on offer in more and more universities and other educational institutions in an attempt to deliver higher quality in learning. The starting point of the implementation of distance education was in 1874. The University of Illinois has since been offering correspondence studies. It is certain however that since 1874 technology and its applications in learning has dramatically changed. E-learning as learning process in general is a not a simple issue. There are many stakeholders, and they are related within the learning environment. Tutors/teachers, administration and authorities, students learners, parents, and institutions all have a different point of view on the whole system. The similarities and the differences between education, teaching, and learning are quite ambiguous (Kroksmark, 1995). As a result, education is the science of training, and respectively learning is the science of teaching. The definition of education includes the complex procedures of teaching and learning, where teaching all the differentiated duties of a teacher is concerned.

The term "e-learning" refers to the use of Internet technologies in order to share information and enhance knowledge (Liaw, Huang, & Chen, 1996). According to Rosenberg (2001), an e-learning system has the following characteristics:

- It is based on a network,
- It focuses on the broadest view of learning
- The participants use computers to get information and knowledge.

E-learning is not the end to classroom training. In fact, classroom training will be redefined to focus on those aspects of learning that are best accomplished when:

- Person-to-person interactions are required
- Opportunities for learning improvements need to be identified
- Team efforts are a priority
- Evaluating tasks
- Participation of experts with the group is needed

E-learning provides opportunities for students who may not be able to pursue an academic degree or participate in continuing education programs because of difficulty accessing a traditional educational setting (Messina, 2002). By using a variety of technologies, including correspondence education, distance education, virtual classrooms, computer-mediated communication, and computer-mediated instruction, e-learning connects students and faculty without the constraints of having to be physically present at a conference or on the university or college campus. E-learning offers many distinct advantages to individuals who may find it inconvenient or even impossible to attend traditional educational institutions because of location, work schedules, and/or increasing family obligations. Also, as e-learning class attendance is not required, there is a significant reduction in costs. E-learning is coming to fill the gaps left from conventional learning. In our days, more and more universities and organizations offer e-learning courses (Sanderson, 2002).

BACKGROUND

E-Learning Terminology

A wide range of terms can be found in the literature that are used interchangeably for e-learning. Nichols (2003) discusses terms such as online learning, mixed-mode learning, blended learning, resource-based learning, Web-based, Web-distributed, or Web-capable. According to Sun Microsystems (2002), e-learning spreads across two worlds, namely, the world of information technology and the world of education and training. In general, as the world of e-learning evolves, terms like e-learning, technology-based learning, and Web-based learning are constantly changing and used differently by different organizations and user groups.

According to Urban and Weggen (2000), the term e-learning can be seen from the *technology-based learning* perspective, where e-learning covers a wide set of applications and processes, including computer-based learning, Web-based learning, virtual classrooms, and digital collaboration. E-learning can be defined as the delivery of content via all electronic media, including the Internet, Intranets, Extranets, satellite broadcasting, audio/video tape, interactive TV, and CD-ROM. Yet, e-learning is defined more narrowly than *distance learning*, which would include text-based learning and courses conducted via written correspondence. From the *Web-based learning* perspective, the term *online learning* constitutes just one part of technology-based learning and describes learning via Internet, intranet, and extranet. Levels of sophistication of online learning vary. A basic online learning program includes the text and graphics of the course, exercises, testing, and recordkeeping, such as test scores and bookmarks. A sophisticated online learning program includes animations, simulations, audio and video sequences, peer and expert discussion groups, online mentoring, links to material on a corporate intranet or the Web, and communications with corporate education records. Finally, from a *corporate e-learning* perspective, the term *e-training* is also used to describe corporate training conducted via e-learning.

Benefits of E-Learning

Cheong (2002) and Scanlon, Jones, Butcher, Greenberg, Ross, Murphy, and Tosunoglou (1996) refer to the most important e-learning benefits that are listed below:

- Reduction of the educational expenses, which are mostly achieved from the minimization of the personnel commuting and traveling.
- Establishment of a dynamic educational context.
- Possibility of adjusting the parameters of the educational material to the idiosyncrasy of the educating groups.
- Content is fully up-to-date and reliable.
- Nowadays learning is continuously available on a (24/7/365) basis, i.e. availability from anywhere at anytime.
- No delays in the start of the courses.
- Courses are universal. This factor is quite important, especially in multinational companies.
- Creation of virtual communities and communities of practice is supported.
- Scalability is also supported, as far as it concerns the number of the participants.
- Leverage of a company's investment in the information technology field is achieved.
- Increase of value added to customers' service.
- Brings dynamic role changes in stakeholders (i.e., lecturers, students, parents, etc.).

Zhang, Zhao, Zhou, and Nunamaker (2004) discussed the advantages and disadvantages of both traditional learning and e-learning, which are shown in the following tables.

Communication in the form of either of class discussion or of immediate feedback is presented in Tables 1 and 2 as distinguishing factors between traditional learning and e-learning. This article focuses on the communication issue and investigates if e-learning can contribute towards effective communication.

Table 1. Advantages after comparing traditional teaching and e-learning

Advantages of Traditional Classroom Learning	Advantages of E-Learning
• Immediate feedback. • Being familiar to both (teacher and learner). • Textbook and reading list. • Class discussion.	• Learner centered and self-paced. • Time and location flexibility. • Cost effective for learners. • Potentially available to global audience. • Unlimited access to knowledge. • Rich multimedia and interactive content.

Table 2. Disadvantages after comparing traditional teaching and e-learning

Disadvantages of Traditional Classroom Learning	Disadvantages of E-Learning
• Instructor oriented. • Location and time constrains. • More expensive to deliver.	• Lack of immediate feedback in asynchronous e-learning. • Increased preparation time for the instructors. • Not comfortable to some people.

Communication as an Important E-Learning Quality Factor

Several research studies have identified a long list of success factors for learning and e-learning. An overview is shown in Table 3.

In addition, Govindasamy (2002) discussed seven e-learning quality benchmarks, namely institutional support, course development, teaching and learning, course structure, student support, faculty support, and evaluation and assessment. From the list of success factors shown in Table 2, communication appears several times as it has been examined from different perspectives. For example, it is the communication among fellow students and among students and lectures as well as the security of communication that enable effective quality learning. Moreover, other success factors, although not explicitly, presume effective communication. For instance, feedback or encouragement from the lecturer implies that there is some kind of a person-to-person or through electronic means communication among interactive parties.

Communication is an important factor in both learning and e-learning that cultivates and strengthens the relationships among students and their lecturers during an e-learning course. Communication is expected to affect students' motivation for learning, for interaction with other students, and for research. The e-learning environment changes the style of communication, not only between teacher and student but also among colearners. As Miller and Padgett (1998) claim, the communication between teachers and learners can be classified to the forms shown in the following table, depending on the time and the place that communication establishes.

Garrison and Shale (1987) declared that educational technology has a vital role, which intermediates in order to achieve a two-way communication between teachers and learners. Additionally, Soong, Chan, Chua, and Loh (2001), identify among other factors communication skills as an important success factor for e-learning.

Highlighting the role of communication in learning, the United States Congress Office of Technology Assessment (1989) defined distance education as an interactive communication among teachers and learners found in different geographic places via the technology. Li (2002) and Offir, Barth, Lev, and Shteinbok (2003) suggest that in order to improve the communication

Table 3. E-learning quality factors

E-Learning Quality Factor	Reference Source
• lecturer's continuous guidance • communication in learning • supervisors' availability • possibility of exchanging opinions among fellow students	• Allen and Eby (2003) • Milliken and Barnes (2002) • Dunken (1983) • Helmi (2002) • Oliver and Omari (2001)
• feedback from lecturer • immediate feedback from lecturer	• Singh (2002) • Lee, Hong, and Ling (2002) • Tuckman (2002) • Driver (2002)
• encouragement from the lecturer	• Grant (2004)
• immediacy effectiveness	• Baker (2004)
• cooperation among students	• Lüthje and Prügl (2006)
• working in groups • communication among fellow students • immediate problem solving	• Larsen and McInerney (2002) • Ritchie and Newby (1989) • Vrasidas (1999) • Phillips and Peters (1999) • Ingram, Biermann, Cannon, Neil, and Waddle (2000) • Volery and Lord (2000)
• secure communication between students and university	• Khadra, Liu, and Shen (2005) • Baylor and Ritchie (2002)

Table 4. Modes of communication

Time	***Place***	
	Same place	*Different place*
Same time	Traditional educational system	Synchronous communication
Different time	Without meaning	Asynchronous communication

among students and their lecturers, the latter should allow for short breaks during lectures so that students would have the opportunity to reflect on the taught material and ask questions. Communication has also been identified as a success factor by Parkinson and Hudson (2002) because it contributes not only during the learning process but also during the design decision making for an e-learning system as they investigate the development of an educational multimedia system. During the learning process of engineering courses, Parkinson and Hudson (2002) found that students need to be aware of the necessity and importance of communicating with working colleagues as experts in their particular industrial role. One way in which students can experience this and become active participants in the learning process is by the use of "virtual environments," which simulate the real working environment. Different technologies are developed and used in order to minimize the distance between teacher and learner. "The lack of contact and consequently, the lack of a high degree of interaction between those involved in the educational process" constitutes the "negative" point of distance education (Panagiotakopoulos et al., 2005).

METHODOLOGY

This study aims at investigating the role of e-learning in supporting communication among students and lecturers. The research was carried out between March 2006 and April 2006 in the Athens University of Economics and Business (AUEB). These students are between 18 and 25 years of age and their studies follow, so far, traditional learning strategies (lectures in classrooms, assessment after every semester). A questionnaire was developed and delivered to 430 students. 412 of them returned valid questionnaires returning a response rate of 95.8%, much higher that the average for such studies of 20%. The high response rate can be attributed to the fact that student had been beforehand informed of the study, and they had agreed to participate and fill in the questionnaire. The questionnaire consists of two sections. The first refers to issues related to students' profile, and the second section includes questions that pertain to the role of e-learning in improving communication. The many facets of communication that a thorough literature review revealed where used in order to form the questions of the questionnaire. Content validity was tested with students and experts in e-learning who have gone through the early versions of the questionnaire. A 5-point Likert scale [Strongly negative (- -), Negative (-), Neutral (0), Positive (+), Strongly positive (++)] was used in order to allow students to express themselves in the most effective way. The research framework of the current study is shown in the Figure 1.

The data analysis was performed with the SPSS 15.0.

DATA ANALYSIS

Reliability Analysis of the Questionnaire

The reliability of the questionnaire was tested with the Cronbach's alpha (a) coefficient. The resulting Alpha = .857 indicates the reliability of the instrument.

Students' Profile

Of the sample, 58.5% are female and 41.5% are male. As regards class attendance, 15.3%, of the students in the sample attend their classes with a frequency of 1–2 days per week. 37.9% of the sample attends their classes no more than 3–4 days per week while 45.1% of the sample attends their lectures every day. This means that most of the students attend the lectures regularly. Figure 2 shows the students' distribution based on their year of studies.

The majority of the students have their own PC (93%). By consulting Table 5 and taking into consideration that the majority of the respondents (93%) have a PC and that they use their PC very often (every day or 2–4 times per week), the study indicates that students of the sample are familiar with the use of computing.

As regards Internet surfing, 26.9% of the sample surfs every day, 54.9% searches the Internet 2–4 times per week, and 11.7% of the students surfs more than 4 times per week. Further, as Figure 3 shows, 68% of the sample is not concerned about viruses when surfing on the Internet.

Despite the fact that security is a main concern of Internet users and fraud is a main issue in Internet business, this study indicates that students in the sample

Figure 1. The conceptual representation of the hypothesized e-learning contribution model

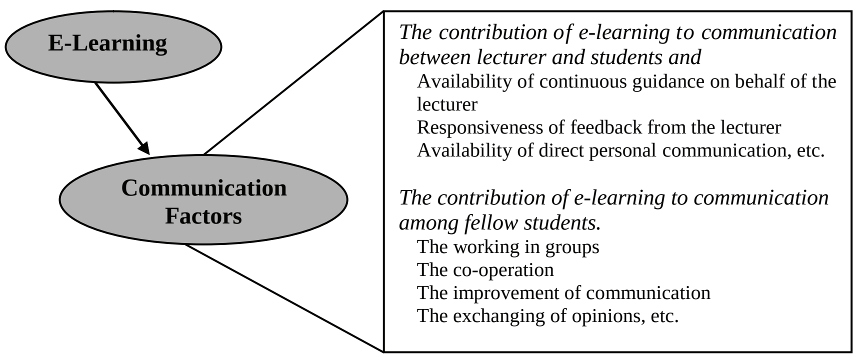


Figure 2. Number of students in the sample per year of studies

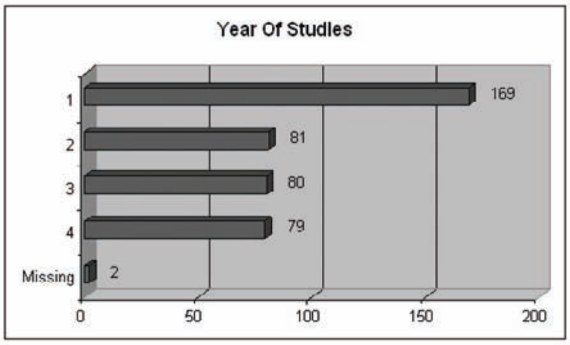
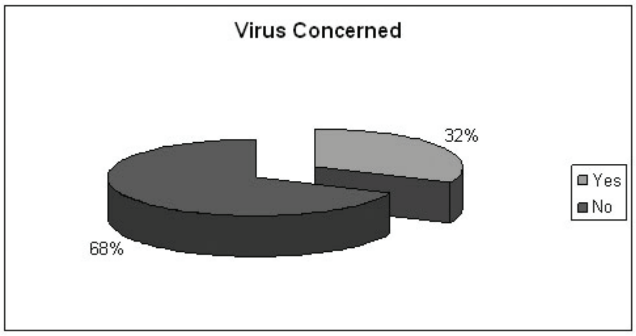


Table 5. Cross-tabulation of PC use vs. PC ownership

Frequency of Using a PC		Own a PC		Total
		Yes	*No*	
Every Day	Count	178	1	179
	%	99,40	0,60	100,00
2–4 times per week	Count	160	24	184
	%	87,00	13,00	100,00
More than 4 times per week	Count	42	0	42
	%	100,00	0,00	100,00
Total	Count	380	25	405
	%	93,80	6,20	100,00

Figure 3. Virus concerned



are prepared to undertake any potential risks; they are prepared to protect their PC, and they go on with the technology and its applications. This may be an issue for further investigation that future generations will have a much different attitude towards technology away from any justifiable or unjustifiable threats. Bearing in mind the students profile, this study suggests that there exists the students' critical mass and students' self-motivation in using e-learning platforms.

Contribution of E-Learning to Communication

This section discusses the potential contribution of e-learning to the communication during the learning process. Although the communication is an issue that can be examined from many different perspectives, this study focuses on:

a. The contribution of e-learning to communication between lecturer and students
b. The contribution of e-learning to communication among fellow students

With respect to the contribution of e-learning to communication between lecturers and students, this study after thorough analysis of the relevant literature investigates the extent of e-learning's contribution to each one of the following aspects that imply facets of communication between lecturers and students:

- Availability of continuous guidance on behalf of the lecturer,
- Responsiveness of feedback from the lecturer,
- Availability of direct personal communication,
- Immediacy of communication,
- Availability of a supervisor during the important project works
- Encouragement from lecturer
- Immediacy effectiveness

Of the sample, 56.9% believes that e-learning contributes positively or strongly positively to the continuous guidance from lecturer to student. Electronic media can be used in order to follow students' performance and allow the lecturers to be better informed and appropriately lead their students to the solution they mostly need.

As Figure 4 shows with regard to the feedback from lecturers, most of the students answered that e-learning has positive contribution to immediate feedback (61.8%). A question expressed by a student can be quickly answered with no need for following a tight schedule of contact hours or for arranging meetings that suit both lecturers and students.

Drawing on findings shown in Figures 9 and 10, the answers indicate that e-learning contributes direct personal communication (53%) as well as improves the immediacy of communication (49.4%). The sample seems indecisive to accept that e-learning contributes to direct communication. From one point of view, e-learning supports communication through electronic media, but from another angle, e-learning thorough e-mails could possibly contribute to arranging direct meetings. This study suggests that the latter is not the point of view that students had in mind when answering the questionnaire. Their positive expectations with respect to e-learning should have been completed with

Figure 4. E-learning contribution to continuous guidance on behalf of the lecturer

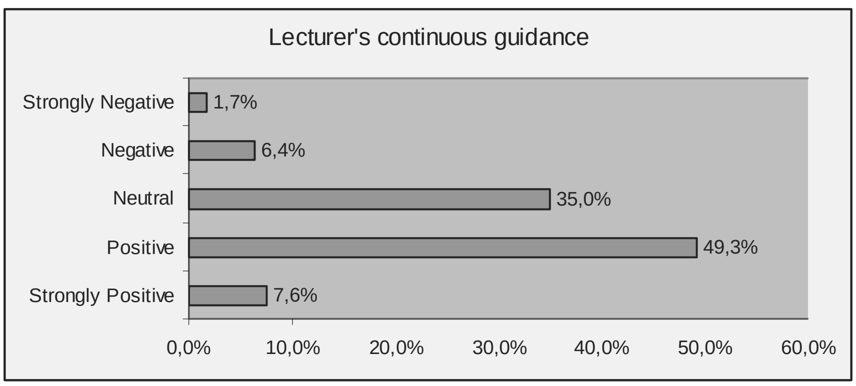


Figure 5. Responsiveness of feedback from the lecturer

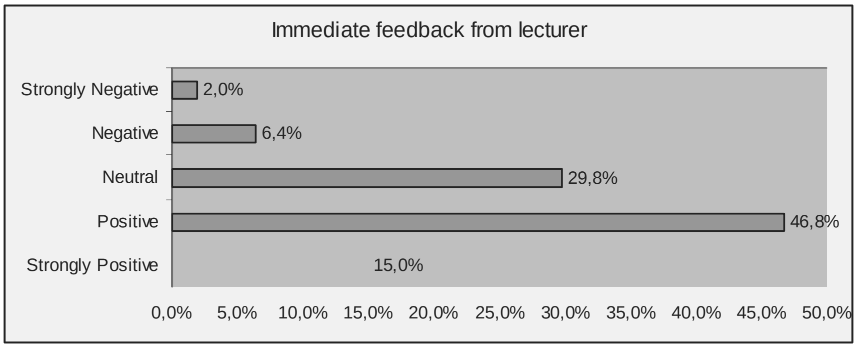


Figure 6. Availability of direct personal communication

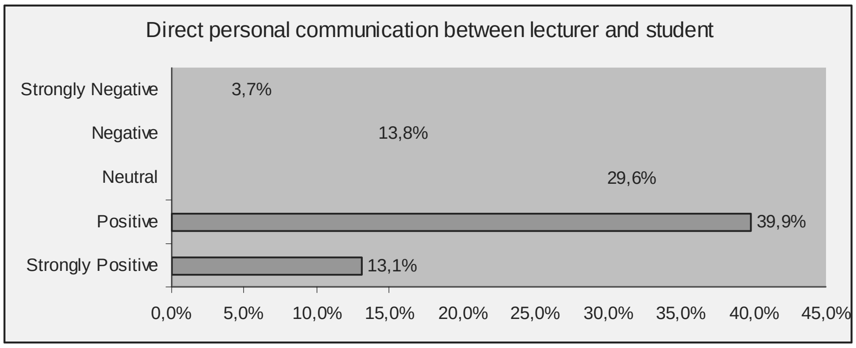


Figure 7. Immediacy of communication

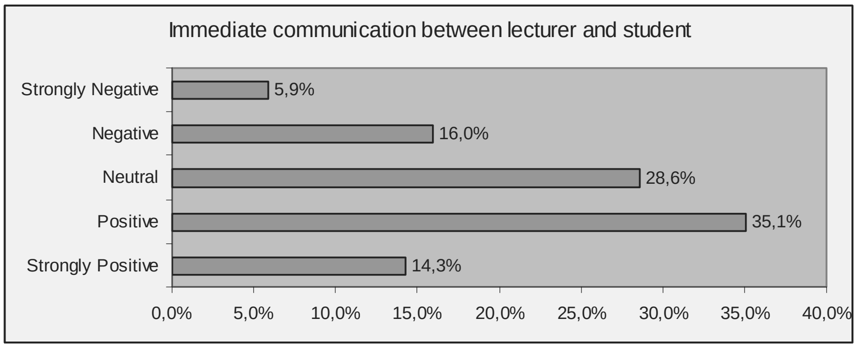


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Figure 8. Availability of a supervisor during the important project works

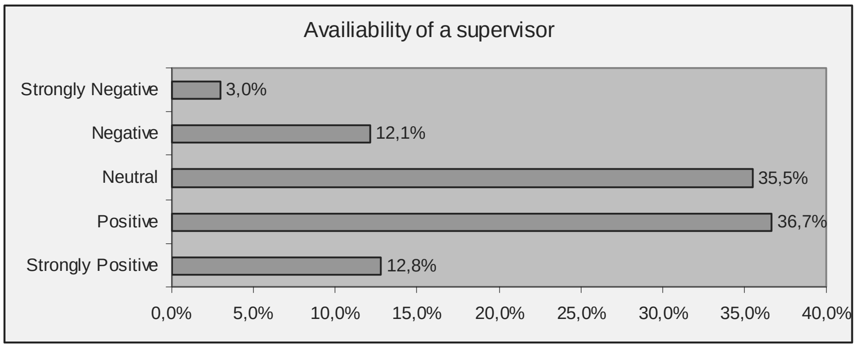
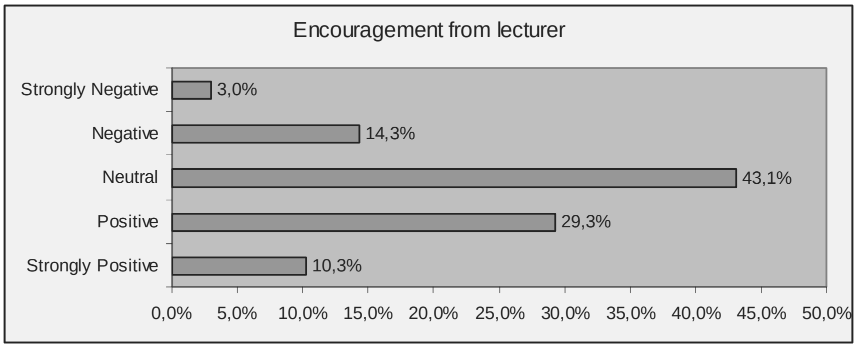


Figure 9. Encouragement from lecturer



e-learning's contribution to guidance and feedback as discussed earlier in this section.

Figure 7 shows that 49.5% of students share the opinion that e-learning enables students to communicate with lecturers through the Internet and approach their supervisor during the development of a project or any other assignment. This is not a very strong positive stance in favor of e-learning, since slightly more than half of the sample does not endorse e-learning value.

Figure 8 shows that only 39.6% of students in the sample express the belief that e-learning improves lecturers' encouragement to students. Instead, 43.1% do not accept that e-learning can have a positive impact. This study indicates that students rather perceive encouragement as a matter of a direct in-person communication. E-learning provides the means of communication in case of well-structured and more regular issues.

The percentage of students, as shown in Figure 9, who believe that e-learning is a positive factor for effective instructors' immediacy (40.9%) is almost the same to the percentage of students who believe that e-learning do not affect instructor's immediacy (40.4%). Effectiveness in communication needs direct communication. Electronic means can be seen as a valuable supplement to effective communication.

With respect to the contribution of e-learning to *communication among students*, this study after thorough analysis of the relevant literature investigates the extent of e-learning's contribution to each one of the following aspects that imply facets of communication among students:

- Working in groups
- Cooperation
- Improvement of communication
- Exchanging opinions
- Immediacy in problem solving
- Security in communication

Of the sample, 49.3% believe that e-learning contributes to working in groups. In this case, students appear indecisive. Those who answered "positively" are

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Figure 10. Immediacy effectiveness

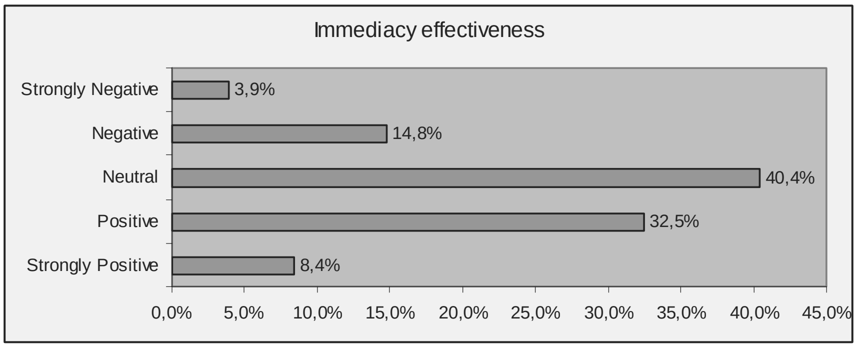


Figure 11. The e-learning contribution to working in groups

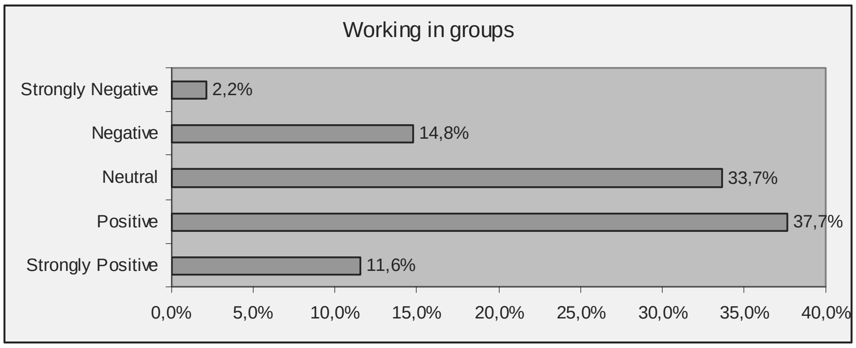


Figure 12. E-learning contribution to cooperating among students

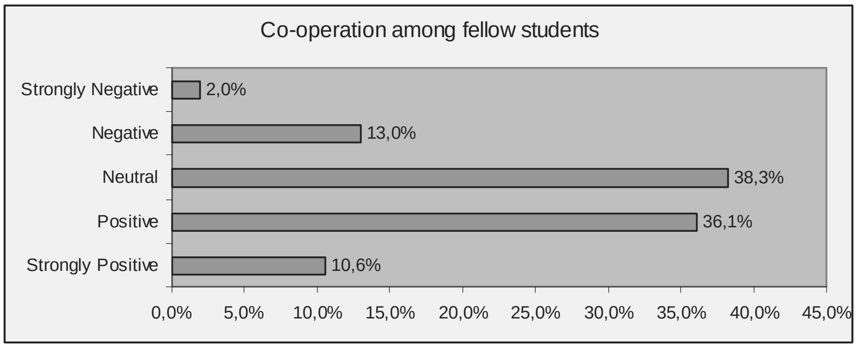


Figure 13. Can e-learning provide the means for improving communication among students?

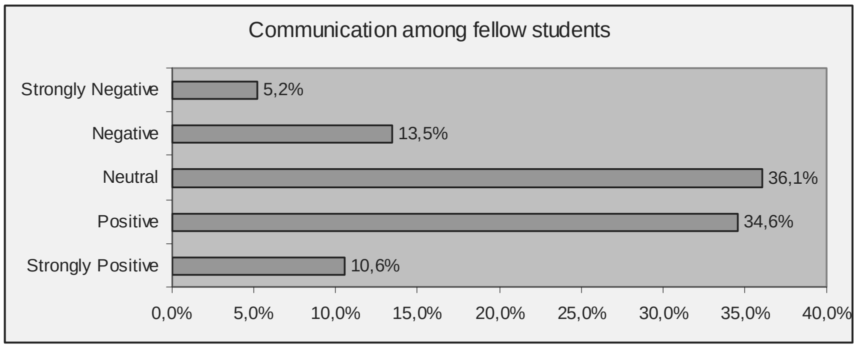


Figure 14. E-learning contribution to exchanging of opinions

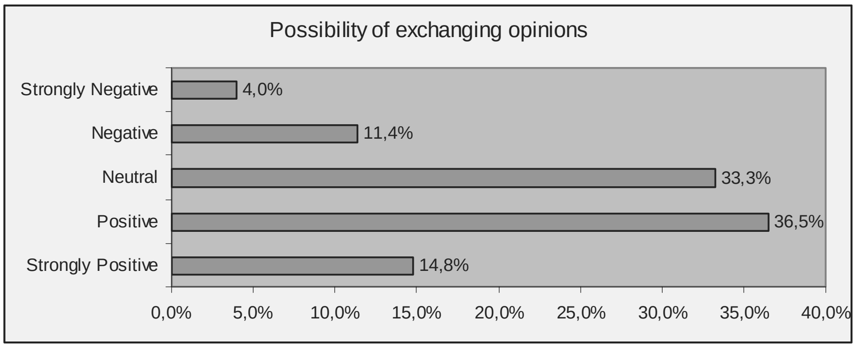


Figure 15. E-learning contribution to the immediacy in problem solving

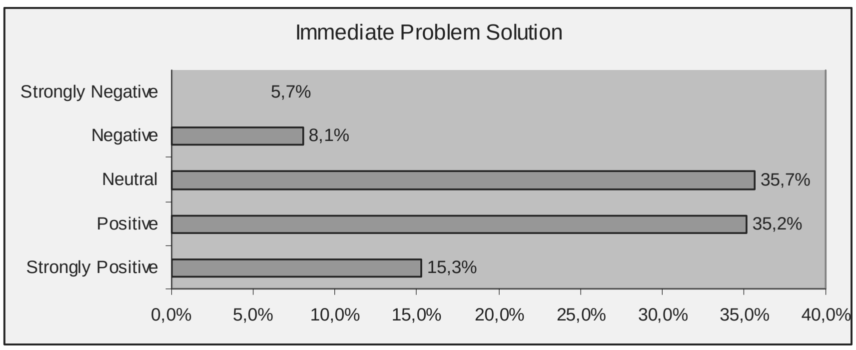
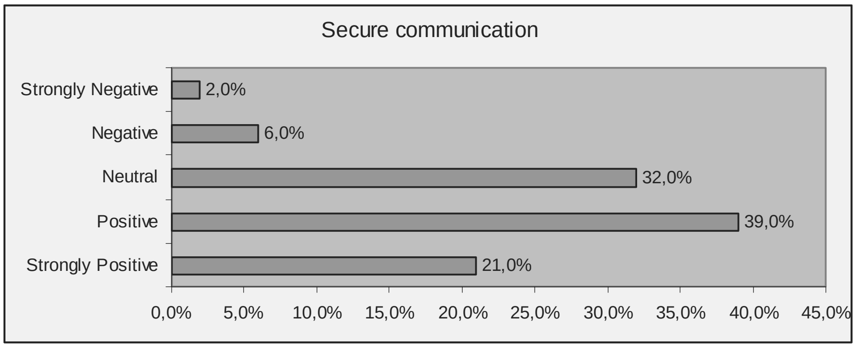


Figure 16. E-learning as a provider of secure communication



almost as many as those students who are "negative" toward accepting the value of e-learning.

This finding needs further investigation in order to examine whether the responses are dependent to students' previous experience with group work. If they are not used to or if they have had indications of poor collaboration, they would have been reluctant to accept group work. A mediocre 46.7% of the sample, as shown in Figure 12, indicates that students are also reluctant with respect to e-learning contribution to cooperation among students. This finding is in line with the previous one, not surprisingly, since group work implies some kind of student cooperation.

Students are even less positive regarding e-learning's contribution to communication among students since only a 45.0% would believe so. Students prefer to form their lively groups and communicate in person.

Students seem to be more in favor of using e-learning as a platform for exchanging opinions. This study indicates that the development of virtual communities as part of an e-learning platform for supporting students would be a good strategy.

Another issue that students with a 50.5% of the sample feel positive about is the expectation that e-learning can contribute toward creating an environment that provides solutions immediately. This finding is in line with previous results that indicate students' belief for responsive feedback on behalf of a lecturer as well as indicate their willingness to exchanging opinions through the technology of e-learning. Quick feedback and opinions sharing at least contribute towards problem solving.

Finally, Figure 15 shows that most of the students (60.8%) answered that e-learning is a positive contributor to the secure communication among the students' community, the university, and among fellow students.

Thus, it means that they trust their communication through e-learning platforms.

HYPOTHESIS TESTING

Further, this section investigates in particular the different views that students may hold when distinguishing them by their beliefs of the importance of e-mail in communication during the learning process. The e-mail based communication was chosen because it is widespread as a communication tool and does not imply any complex technical knowledge and skills when using it. The questionnaire investigates the extent to which students regard e-mail based communication as a critical success factor (CSF) in learning, not only in e-learning. The study then separates the sample into the following two parts:

- The part (A) that represents students who *believe that e-mail based* communication is a CSF for learning.
- The part (B) that represents students who *do not believe that e-mail based* communication is a CSF for learning.

The answers of part (A) subset then were considered in order to further investigate their views with respect to the perceived particular importance of e-learning in the communication among lecturers and students. First, Table 6 shows the percentages of students who believe

Table 6. E-learning and its contribution to effective communication: The views of students who consider lecturer–student communication via e-mail a CSF to learning

… Communication factors	Percentage
... lecturer's continuous guidance	73,2%
... taking feedback from lecturer	75,2%
... taking fast feedback from lecturer	75,2%
... direct personal communication between lecturer and student	67,1%
... immediate communication between lecturer and students	62,4%
... availability of a supervisor	59,7%
... encouragement from the lecturer	47,0%
... immediacy effectiveness	51,7%
... working in groups	50,3%
... cooperation among students	56,4%
... communication among fellow students	52,3%
... possibility of exchanging opinions among fellow students	62,2%
... secure communication between students and university	68,2%
... immediate problem solution	58,1%

"positively" or "strongly positively" that lecturer–student communication via e-mail is a success factor for learning quality, and they also believe that e-learning contributes positively or strongly positively to each of the communication factors in Table 7. Effective contribution to communication factors is defined by student responses as "positively" or "strongly positively."

A first indication is that most of the students with positive rates in lecturer–student communication via e-mail also rated positively the contribution of e-learning to both types of communication. The only exception to this conclusion is the contribution to the encouragement from lecturer where the percentage is lower than 50% of the sample. The study in order to further investigate the above indication continues with chi-square tests (in Table 7) and examines the following type of hypothesis.

H1: Does e learning contributes toward effective communication?

Effective communication is considered in terms of the communication factors shown in Table 7.

This study indicates that there is no statistical significance to assume that e-learning contributes to encouragement from the lecturer, communication among fellow students, and opinions exchanging, which are highlighted in Table 7. However, this study indicates that there is statistically significant dependence between e-learning and communication that would support aspects of H1 hypothesis.

FUTURE RESEARCH

This study investigates the contribution of e-learning to communication. However, this topic has been investigated in an exploratory manner. Communication may differ among different cultures, among mature students, and it depends on many other factors that are not studied in this research work. For future research, the development and validation of a model that captures the interrelationships between learning quality factors and their contribution to communications in different organizational, cultural, and educational level settings may shed more light into this topic. Furthermore, the development of customizable e-learning environments may also become the necessary infrastructure for enhancing communication among all members involved in the learning process.

Table 7. E-learning contributes to communication among lecturers and students

Communication factors related with lecturer–student communication via e-mail	Significance value
lecturer's continuous guidance	.000
taking feedback from lecturer	.001
taking fast feedback from lecturer	.000
direct personal communication between lecturer and student	.000
immediate communication between lecturer and students	.000
availability of a supervisor	.000
encouragement from the lecturer	**.010**
immediacy effectiveness	.001
working in groups	.000
cooperation among students	.001
communication among fellow students	**.020**
possibility of exchanging opinions among fellow students	**.013**
secure communication between students and university	.000
immediate problem solution	.005

CONCLUSION

There has been a wide range of publications that investigate e-learning and learning effectiveness. This study focuses on e-learning and its contribution to communication in Greece. Therefore, the results indicate that e-learning is an opportunity for supporting communication especially among e-learning students as well as among lectures and students. This study indicates several aspects of communication and found strong indications that students could exploit e-learning, for example, through e-mail for establishing effective communication links within the learning process. However, there is no statistically significant relationship that would imply that students find the possibility to exchange ideas and opinions through an e-learning platform would be a promising application, thus leading to the development of virtual communities for students support, problem solving, brainstorming, and so forth. It may be thought of as a significant supplement to traditional learning approaches, but it could also be seen as a driving force for improving communication for those students who are not only familiar with new IT technologies but are also in favor of e-learning. Therefore, e-learning should be further developed internationally and in particular in Greece, where the data are collected. Further research will contribute to better understanding in designing e-learning courses.

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KEY TERMS

Communication: The process of exchanging information and ideas. It involves encoding, transmitting, and decoding intended messages.

E-Learning: The acquisition and the use of knowledge distributed and facilitated primarily by electronic means. This form of learning currently depends on networks and computers but will likely evolve into systems consisting of a variety of channels (e.g., wireless, satellite) and technologies (e.g., cellular phones, PDAs) as they are developed and adopted. E-learning can take the forms of courses as well as modules and smaller learning objects. E-learning may incorporate synchronous or asynchronous access and may be distributed geographically with varied limits of time.

E-Training: The corporate training conducted via e-learning.

Online Learning: Constitutes just one part of technology-based learning and describes learning via Internet, intranet, and extranet.

Problem Solving: A systematic approach utilizing multiple perspectives to uncover the issues related to a particular problem, design an intervention plan, and evaluate the outcome.

Quality Learning: An approach to improving learning and the quality of organisational life.

Service Quality: It is argued that businesses need not only correspond to their customers' needs but also extend their customers expectations.

Web-Based Learning: Used synonymously as online learning.

E-Learning is What Kind of Learning?

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INTRODUCTION

The knowledge society has reinterpreted the concept of knowledge, shifting from the idea of philosophical argument to an epistemological meaning linked to educational actions. Knowledge is now diffuse, not centralized, and more accessible than ever before, and learning approaches involve visual processes and nontraditional languages. This has led to a radical change in the way knowledge is transferred, away from intentional transgenerational transmission and toward self-directed learning, simplified by multimedia and technological resources.

According to current learning theories, knowledge construction may be defined as a mediative process between adaptive learning dynamics at both the individual and collective level. Research on knowledge construction has combined social contextualisation and constructivism to achieve a sociocultural view of the distributed mind. At the same time, cultural embeddedness and domain-specific situativity are interconnected with mind embodiment and the view of the environment as a holistic and synergic organism. From an educational point of view improving guidance in a diffuse knowledge society is definitely a very difficult task, notwithstanding the fact that knowledge may seem relatively easy to approach. Diffuse knowledge can be highly specialised, and may require the ability to transfer and generalise learning in order to link the various aspects that are examined. At the same time, knowledge must be contextualized if we want to identify motivational implications and, more importantly, show its actual usability at experiential level.

As technology is bound to evolutionary changes taking place in contexts within which and by which it is produced and which it produces, it is potentially "disorientating", thus becoming an object for study in pedagogical terms. It is worth considering also that it is not always easy to predict how a complex and reticular society will evolve, and that unstructured or poorly structured problems and situations may arise which are often difficult to systematise and/or categorise. This type of problematic situation points to the need to train new knowledge workers to replace those who, in the past, were used to dealing with situations that, however complex, were somehow "ordered" and predictable in the dynamics of their evolution.

Social and cultural transformations, education and training needs and technology appear to be closely interconnected, hence they should be the factors determining the new ICT solutions proposed. Pedagogy should precede technology in the sense that while technology suggests, experiments and makes available advances in ICT and new products, it is up to pedagogy to decide which advances and which solutions may actually bring about an effective development of the learning potential and of the cognitive, communicative and adaptive resources of the individual with due regard for different experiences, contexts, and evolutions.

Over the last few years the use of information and communication technology (ICT) in education and training has led to a reformulation of the teaching-learning relationship dynamics, shifting from a mere transposition of existing theories and models to the virtual world. This strand of research has shown that designing virtual learning environments is today one of the most meaningful and fascinating areas of education and technology, as regards both online and offline learning with ICT support (Frauenfelder & Santoianni, 2006).

The design of virtual learning environments cannot shy from the task of analysing, assessing and, where necessary, reformulating teaching-learning models; this line of research must also discuss what kind of learning e-learning actually is. There is no other way to approach the design of learning models which reflect the deep transformation of knowledge that is coming about, also in the virtual world.

CLASSICAL MODELS FOR TEACHING, LEARNING—AND E-LEARNING?

In technology, constructivism appears to be particularly effective when associated with a social as well as cultural interpretation of knowledge. Though these two points of view have traditionally been kept quite distinct, integration of these two strands of research now seems likely to be opening up interesting interpretative multiplicities. This integration makes synergic reconsideration possible on the part of the learner (Table 1) leading to the development of learning pathways orientated towards concrete learning supported by a social vision of the construction of the learning environment.

Toward a Socioconstructivist Approach

In actual fact, sociocultural theories and constructivist perspectives on learning diverge not only in epistemological terms—with different interpretations of knowledge—but also in ontological terms—as far as the known world/world to know and the knowing subject are concerned (Packer & Goicoechea, 2000).

From an epistemological point of view, sociocultural theories highlight the role of social participation in learning. At the forefront is the educational and training relationship itself—no longer merely who is doing the teaching (teacher-centred approaches) or who is doing the learning (student-centred approaches). It is an embedded, dynamic educational and training relationship, in which trainers are considered *experts,* skilled in managing historical change and organising social activity. In this framework cognitive responsibility is given to learners, who—in a process of *apprenticeship* and collaboration—must search for their own identity in the learning community through constant reference to the models that are available within.

Table 1. The learner from a socio-constructivist point of view

The socio-constructivistic learner may be considered as: ▪ planner ▪ explorer ▪ apprentice ▪ meta-reflective thinker ▪ member of a community

Constructivist perspectives, on the other hand, study the adaptive features which regulate the development of knowledge based on the actions and interactions of the subject in the world. In doing so, while not neglecting the role played by the social context in knowledge construction, they focus on the relation of productive interaction between self and the environment and the reciprocal transformative potential implied in this relation (Gros, 2002). The subject, then, is an explorer of pathways of guided discovery, planning strategies, itineraries, learning environments and the adaptive mode to interact. Besides considering the subject as generally interactive, which lies at the basis of the historical-social matrix, it tends towards the idea that each subject will interact with others, with the symbolic systems and "tools" of knowing, shifting from a biological to a socio-cultural metaphor of knowing (Sternberg, 1990).

In an interactivist perspective (Gottlieb, 1996; Lerner, 1998), however, the two metaphors are not necessarily contradictory, far from it; it is precisely from a pedagogic standpoint that approaches such as bioeducational sciences (Frauenfelder, Santoianni, 2003) promote a global and synergic vision.

Conversely, the possible complementary nature of sociocultural and constructivist approaches recently identified is based—from an ontological perspective—on the idea that the constructivist dualism between the knower and the known is no longer justified, insofar as knowledge itself cannot be considered as a world in itself but a world coconstructed by several individuals. These individuals, recognizing themselves as a part of that world, are both transformers of it and transformed by it.

It is precisely through this contact with the learning community—a necessary step towards a feeling of belonging—that the learner rediscovers his or her sense of individuality, often taken for granted in sociocultural approaches *tout court* and often exclusive in constructivist approaches *tout court.* As these tendencies are negotiated, new ideas emerge along with fresh modes of interpretation and innovative operative pointers for the design of socioconstructivist virtual and nonvirtual learning environments.

The socioconstructivist approach highlights the dynamics of mutual interaction between:

- **Culture:** Meaning a set of symbolic systems, cognitive artefacts, expressions of knowing, and so forth.

- **Cognition:** Meaning a set of individual variables in the processes of sharing and co-constructing knowledge.

These dynamics become particularly evident with the use of "peripheral devices", that is information and communication technologies which bring together the individual and social value of knowing through new forms of interaction.

The influence of the socioconstructivist approach on designing multimedia learning environments can thus activate a synthesis of two of the possible meanings that may be attributed to the learner:

- The concept of *designer*, learning through guided discovery
- The concept of *apprentice*, learning in/from the learning community

In terms of technology, this might mean, for example, the 'combined' use of cognitive tools (databases, worksheets, conceptual networks, hypertext, etc.) and communication tools (forum, chat, mailing list, etc.) for the design of virtual socioconstructivist learning environments.

RESEARCH TRENDS IN E-LEARNING DESIGN

Designing learning environments both online and offline obviously means being influenced by the enormous changes and shifts which implement learning whether knowledge is considered as:

- Distributed
- Embodied
- Situated

The quality of training, especially when linked to technology, may be increased by strands of research which take into account all three of these diverse (and yet interconnected) aspects of knowledge synergically. All of these bring forth fresh ideas which force the learner, one way or another, to reconsider role of the learner in the learning relationship.

New Ideas: In Search of New Perspectives for the Mind

E

Distributed Knowledge

The distributed nature of knowledge makes the passage from *learning processes* to *knowledge structures* easier (Bereiter & Scardamalia, 1998). This occurs by opening up the individual cognitive learning environment and subjective experiential modality to an idea of co-constructed knowledge.

There are two renewal factors:

- One concerns the interpretative revision of the knowledge implied in the passage from cognitivism to postcognitivism and consequent to the reformulation of the subject's role within the teaching-learning relationship.
- The other concerns the need to consider the balancing of these two elements of the relationship, both of which are constantly involved, interacting, and shifting adaptively in the individual and social coconstruction of knowledge.

Embodied Knowledge

If we are to hope—as we indeed do—that the learner is to be *active* within the process, the learner must be provided with a learning environment "to transform" that can be effectively transformed on the basis of the learner's needs. The cognitive processes are actually thought to be on demand, that is, they can be adjusted according to the requirements of the environment, on the basis of which individuals perfect their own operative strategies. At the same time the reciprocal nature of the adaptive relationship—what is defined as *structural coupling* (Riegler, 2002)—means that individuals too develop their own needs, independent of the requirements of the environment—needs which lead them to try out what the environment has to offer and, if necessary, to attempt to modify it accordingly.

In this sense e-learning environments may be adaptive—just as all learning environments generally speaking are (Santoianni, 2006)—if they allow the user to perform a transformative action upon them, for example, to choose autonomously the pathway to take or to have the chance to supply a personal and productive response within the processes implemented by the system. Experience of meaningful learning in complex systems/environments points to the development of the capacity to *construct* models, not simply *use* them.

Situated Knowledge

The idea of situativity highlights the *implicit* component of learning, which—like explicit functions (Stadler & Frensch, 1998)—orientates knowledge. However, while explicit functions are well known and have been widely studied, the sphere of the implicit still makes the object of research, since there is no clear understanding as to how the implicit is absorbed or about the evolutive power it wields in the long term, influencing and modifying behaviour.

The implicit regards a multitude of expressive levels and requires reconsidering both the presumed "distance" between emotional and cognitive elaboration, and the presumed "hierarchy" between perception and "higher" levels of cognition (Santoianni & Sabatano, 2007). As a result, cognition concerns a functional system in its entirety.

While this viewpoint might suggest a considerable number of pointers to change, it also throws up a series of problems on how to "transfer" these ideas into the field of technology and more specifically of e-learning systems design.

How can knowledge actually be bound to action, to contingency, to the body, if the aim is to design an educational tool like e-learning which, by its very nature, is often asynchronous or broken up into a whole range of events which may be face to face, synchronous, shared, coconstructed, in the classroom, stand alone, asynchronous, managed by single subjects in line with individual modality and strategy (though mediated by communication tools such as forums, chats, mailing lists)?

Aside from the tentative basic premise that an integrated educational tool—which includes both asynchronous phases of individual study and knowledge-sharing in the classroom—would appear to be one of the most effective modes of e-learning, the problem here regards the need to design learning environments where the "body" is present as a transformative, structuring, and restructuring action upon the environment itself.

In line with an idea of socioconstructivism, planning, and modelling should be carried out on shared products/processes in collaborative systems/environments (van Joolingen, 2000). In this sense, collaborative activities should include features like (Jonassen, 2000):

- Construction
- Coconstruction
- Metareflection
- Multimodal interaction
- Authenticity

The effectiveness of a learning environment, then, if it is to be structured in such a way as to be distributed, situated and embodied—even within an e-learning environment—depends largely on its potential to implement constructive and interactive approaches and, above all, should be identified progressively, along the lines of a dynamic and, of course, adaptive design.

E-Learning Environments Design: Practical implications

An e-learning environment should be:

- **Distributed:** It fosters the sharing of learning experiences by means of forums, chat and cognitive artefacts like organizer, notice board, and so forth.
- **Embodied:** It lets students participate in training choices, and is modifiable; offers several pathways and can be coconstructed
- **Situated:** It orientates contents towards case analysis; includes repositories of learning experiences
- **Biologically oriented:**
    - o Multimodal at the perception level, using voice files, interface communication programs, and so forth.
    - o Multivaried at the processing level, with diversified pathways for memories, also with implicit structure, with different space organisation of contents, and so forth.

CONCLUSION

The concept of *construction* means "working" on knowledge of an active and collaborative nature, which includes both *participation*—the ability to share, discuss, negotiate—and *adaptation*—the capacity to become part of an environment and to "react" to it, responding to what the environment has to offer but also transforming it by proposing fresh solutions. This interpretative complexity is crucial in understanding the sense of constructivism which expresses itself, even in a technological environment, in its dual significance—Vygotskian and Piagetian—through learning communities, projects and the design of learning paths which represent learning environments modulated and modelled for the construction of knowledge.

Personal ways of managing knowledge should be placed in relation to *collective* criteria of representation of that knowledge (Chen & Hung, 2002), since it is in the relationship between the individual processes of understanding meaning and the collective process of the sharing, negotiation and coconstruction of these individual processes that knowledge is "formed"—in the sense that learning interactions take shape and "open up" the field to pedagogy.

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KEY TERMS

Adaptive Learning Environments: The processes of acquiring and managing knowledge may take place in dynamic and adaptive learning environments, where the focus is on the relationships and modes of interaction between teacher and learner, between the learner and the learning environment. Aspects which make a learning environment *adaptive* are bound to the evolving nature, seldom fully predictable, of cognition and its correlative nature, between the individual and the community. Adaptive learning environments may be considered flexible environments where the design of learning aims is by its very nature dynamic.

Bioeducational Sciences: *Bioeducational sciences* can be seen as an emerging field of research which links neuroscience, biological sciences and educational perspectives on shared focuses to deal with the problem of mind education in epigenesis. At the heart of bioeducational sciences lies the study of mind development from an educational point of view. Bioeducational sciences aim to develop integrated research approaches to find out what kind of constraints may influence individual modifiability and relative plasticity in educational development.

Constructivism: The concept of "construction" implies transformative "working" on knowledge; an active and reactive task of acquiring, processing and producing knowledge which puts the learner in a key position in the learning process—in other words aware of how the process itself works; capable of managing, proposing, and being creative. In the technological field the constructivist viewpoint is particularly effective precisely because of its interpretative multiplicity, which lends itself to a reconsideration of the learner as designer, metareflective thinker and community member—leading to an *integrated* vision of learning environments design.

Distributed Mind: Knowledge is *distributed*—among minds, in the intersubjectivity of thought; among the "peripheral devices" that represent the "extensions" of the mind, like technology; among the "cognitive artefacts", coconstructed cultural products, domain specific and relative to the contexts from which they emerge and in which they are formed.

Educability: *Educability* may be considered as a complex process concerning individual adaptive learning potential to cope with environments, explicit and/or implicit conditions of interaction in designed or nondesigned learning environments, and the role of personal history in these experiential dynamics. Educability is the process which concerns the criteria whereby it is possible to "form" the mind in epigenesis by activating paths which may regulate and transform learning. Management and transformation activities are therefore hypothesized, designed, and developed keeping in mind the potential variables of adaptive systems and of their development processes.

Embodied Mind: Knowledge is *embodied*, within the body and "organismicity" of the learner and of the environment in which the learner is synergically included, within a correlative vision of the interdependent relationships between mind and brain.

Situated Mind: Knowledge is *embedded* in space-time situativity and within the contingency of the various learning situations, where experiential interaction is regulated by evolving and adaptive criteria.

E-Learning Methodological Models and Typologies

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INTRODUCTION

Since the beginning of the new millennium the term e-learning has received growing attention in the area of technology-enhanced education. The term, which literally means "electronic learning", can be defined as "an innovative approach for delivering well-designed, learner-centered, interactive, and facilitated learning environment to anyone, anyplace, anytime by utilizing the attributes and resources of various digital technologies along with other forms of learning materials suited for open, flexible and distributed learning environment" (Khan, 2004).

Besides this wide definition, it can be identified different e-learning methodologies from a pedagogical perspective. More specifically, in the field of formal e-learning a broadly accepted classification introduced by Mason (1998, 2002), distinguishes between three main models: Content + Support, Wrap Around, and Integrated (Anderson & Elloumi, 2004; Bellier, 2001; Calvani & Rotta, 2000; Khan, 1997, 2004; Ranieri, 2005)

This article aims to examine these different e-learning models and discuss some recent evolutions in this field due to the development of online learning communities (Palloff & Pratt, 1999) and the diffusion of social networking practices that have emerged in the Web in recent years (Bonaiuti, 2006).

A REVIEW OF E-LEARNING MODELS

Content + Support Model

The Content + Support model is the more common solution for online courses. It may also be inexpensive if the multimedia and interactivity levels of the instructional contents are not complex. This model is based on contents delivery (i.e., printed materials or Web pages) with minimal support of the e-tutor (by e-mail or computer conferencing). It is characterized by the separation of content and support and is oriented towards individual learning.

In this model the Internet is mainly considered a channel to transmit learning contents. The theoretical framework involved in this approach is teaching by merely transferring information. In addition, the learning goal is already defined and participants do not contribute to the process of defining objectives, through negotiation and knowledge construction.

The contents delivery may be either synchronous or asynchronous.

A – Synchronous Delivery (Live)

Typically, a synchronous delivery system is represented by an audio/videoconferencing where both the sender and receiver share the same temporal mode for interaction.

The specific value of a synchronous delivery system is that it allows the interaction between people in different locations in real time. For example, a subject expert may give a lecture at a distance, and remote students may arrange for a session during which they pose their questions which are then answered by the experts. Without this minimal interaction between expert and students the conference could be considered just a simple streaming. Furthermore it must be observed that this delivery system may encounter problems of accessibility. For example, full dual communication and interaction by videoconferencing is limited by the band constraints, which may prevent a certain number of people from participating in live events. It is much easier instead to manage a full dual communication with only audio and static images transfer (e.g., synchronized slideshows). Technologies such as Centra, for example, enable easy management of full dual communications.

In all ways, this e-learning model allows a low interaction level being limited by the same constraints of traditional F2F classrooms, such as:

a. Students having to meet at the same time; meaning that there would be just one session for students who may have the most diverse needs;
b. Limited time available for discussions; meaning that not all may have the opportunity to interact.

The Content + Support model foreshadows the so-called t-learning solutions based on digital TV. However, even if interactive television could be used, interaction will be limited to just a few people because of the typical inherent limits of synchronous delivery systems.

There are some cases where the delivery of a live session during a course could be useful with the purpose of animating a community—a class or a group—which demonstrates socialization problems.

It would be possible to obtain positive results by integrating live events with asynchronous communication tools system: for example, an e-tutor launches a discussion in a Web forum; the students pose questions that are collected, and then in a live event an expert answers the questions and eventually the students achieve their tasks (producing a paper, creating a product, and so on) working in an asynchronous way.

B – Asynchronous Delivery

This kind of delivery system is characterized by the supplying of instructional, structured units of learning. In this case, the main issue is to provide learners with something other than printed materials. But at the same time, the production of instructional content with high multimedia and interactivity levels is very expensive. Moreover, this type of instructional material often encounters accessibility problems, and at times can only be used off-line.

However, as in the case of multimedia contents, it is essential to follow the methods and the recommendations of the multimedia learning in order to ensure good instructional communication (Clark & Mayer, 2003; Mayer, 2001). Even if this aspect has been widely investigated, it continues to be a critical issue. A casual and linear relationship does not exist between interactivity and learning in that more interactivity entails a higher level of learning. In certain cases, a superfluous use of multimedia can produce cognitive overload, thus interfering with the learning process.

The greatest strength of this approach may consist in the opportunity to combine a variety of instructional units and components to support individual instructional goals.

The learning object's philosophy involves a similar view. It aims at providing small instructional components that can be reused a number of times in different learning contexts. The notion of small, reusable chunks of instructional media, which can be reassembled in different ways, suggests an arguable interpretation of the nature of knowledge as being auto-consistent. This is a very critical issue contrasting with the real nature of learning and knowledge. As research points out, learning is a situated process and knowledge does not consist at all of a composition of auto-consistent objects (Fini & Vanni, 2004).

The growing interest in learning object philosophy comes along with a growing attention for tracking systems which have received too much attention in the last years.

As noted previously, the Content + Support model is oriented towards instructional materials. They should be adequately comprehensive in order to reduce the human actors support. Therefore the Content + Support approach could provide economic benefits in a course with numerous students by reducing the e-tutoring costs. In this case, the e-tutor's role is of the "pull" kind, the e-tutor intervenes on-demand, like a "call center" operator. In addition the e-tutor normally applies techniques and devices for the efficient management of messages (e.g., FAQs).

Wrap Around Model

Whereas the Content + Support model is that which "common sense" normally envisions when thinking of e-learning, practitioners coming from the educational field demonstrate a strong reluctance toward this model. It is content oriented and presupposes that teaching consists in transmitting knowledge and learning or, otherwise stated, in merely memorizing and processing information. Hence there is no attention to the crucial dimensions of learning such as critical thinking and metacognitive skills.

Instead, from Piaget's theory on the more recent constructivism, learning is seen as an active process by which learners construct new ideas or concepts based on their present and past knowledge and experiences. As Cunningham and Duffy outline (1996, p. 172), all constructivist theories share the principle that "learning is an active process of constructing rather than acquiring knowledge and instruction is a process of supporting that construction rather than communicating knowledge." According to constructivism, in an authentic environment learners assume the responsibilities of their own learning and develop metacognitive abilities in order to monitor and direct their own learning and performance. Therefore an authentic environment is an open and flexible learning space where learning goals may be defined in itinere (including new resources, concepts and reflections).

In this perspective the Web enables to shift attention from contents to content's "wrap around" aspects. Rather than delivering teaching materials, the focus is on learning activities. The Web may play the role of a trigger factor, raising problems as well as providing resources and support for their solutions. The instructional contents may have differents formats, from traditional (such as books) to new ones (such as digital resources). They cannot be defined from the beginning, because they can be expanded and enriched by the Web, which is a very large repository of documents and resources.

The e-tutor can present problems to solve or demonstrate how to solve problems, providing information, resources, and adding new ongoing elements and suggestions.

Among the asynchronous communication tools, the Web Forum becomes crucial as a common space where learners can work collaboratively and share their reflections and products of learning.

The Wrap Around model is the more suitable solution for academic courses, especially (but not exclusively) in the field of humanistic studies. The starting investment may be really low. Anyway it is important for the role of the e-tutor to be proactive, able to manage communication tools, moderate interaction, add documents and resources, and animate the virtual classroom.

Integrated (or Collaborative) Model

The third model can be seen as an evolution of the Wrap Around model and relies on collaborative work. In this case the emphasis is on the virtual classroom and knowledge sharing processes (Harasim, 1990, 1995; Trentin, 2004).

The theoretical framework involved in the Integrated model is related to contructivism, just like the Wrap Around model. In particular, it refers to social constructivism theories of learning which emphasize the social nature of learning and knowledge and the value of collaboration and social negotiation among learners.

The course contents are typically ill defined and dynamic. There is no distinction between contents and support because contents emerge just from the interaction and negotiation among e-tutor and learners or among the community of learners. The e-tutor plays the role of moderator and animator of the learning community.

In some cases the group's work can be based on collaborative and/or cooperatives activities in a strict sense. Although the word "collaboration" is often used abusively to refer to any kind of teamwork, scholars usually distinguish between "collaboration" and "cooperation". Both collaboration and cooperation involve a team-based working process with a common goal, but collaboration takes place through continuously mutual and shared interaction and negotiation, while cooperation can be accomplished by the division of labour among participants and each person is responsible for a portion of the work (Strijbos & Martens, 2001).

Therefore collaboration is really difficult and online collaborative work even more. Just to demonstrate some critical issues, as reference literature points out (Calvani, 2005; Dillenbourg, Baker, Blaye, & O'Malley, 1996; Jonassen, 2000), online collaboration endures the mediatization of the interaction context, has to afford the problems of trust and reputation, requires group culture development and social grounding, and so forth. Hence, online collaboration is complex and challenging and requires the achievement of many conditions to make it efficient.

Briefly, the differences between the three e-learning models can be synthesized as in Table 1.

TOWARDS E-LEARNING 2.0

E-learning is continuously evolving. A promising perspective is provided by the recent development of informal e-learning enabled by a new generation of technological tools and devices: the so called Web 2.0 (wiki, blog, podcast, Web syndication, social tagging, etc.).

Table 1. E-learning models

Content + Support Model	Wrap Around Model	Integrated Model
Focused on learning content	Focused on learner	Focused on learning groups
Based on content delivery	Based on learning activities and different kind of resources	Based on collaborative activities
Oriented towards individual learning	Oriented towards individual learning and small group activities	Oriented towards collaborative learning groups
Low level of interaction with the e-tutor	Meaningful interactions with the e-tutor	Peer tutoring
No interaction and collaboration with other learners	Interaction with other learners	Peer learning

This perspective, based on the assumption that the "Web is the platform" and referred to as "e-learning 2.0" (Downes, 2005), improves personal informal relationships and a flexible integration of new web tools. It suggests a kind of migration from traditional Learning Management System (LMS) to Personal Learning Environment (Tosh & Werdmuller 2004; Wilson et al. 2007).

A Personal Learning Environment (PLE) can be defined as "a single user's e-learning system that provides access to a variety of learning resources, and that may provide access to learners and teachers who use other PLEs and/or VLEs" (van Harmelen, 2006, p. 1).

The interest in PLE is motivated by differents factors, such as (van Harmelen, 2006, p. 1):

- "The needs of life-long learners for a system that provides a standard interface to different institutions' e-learning systems, and that allows portfolio information to be maintained across institutions.
- A response to pedagogic approaches which require that learner's e-learning systems need to be under the control of the learners themselves.
- The needs of learners who sometimes perform learning activities offline, for example via mobile system in a wireless-free hospital, or on a remote mountainside."

Unlike LMS, which supposes a course-centred vision of learning, a PLE enables students to manage and control their learning processes and objectives, and allows the integration of both informal and formal experiences (Bonaiuti, 2006).

Moving from the analysis of Wilson, Liber, Johnson, Beauvoir, Sharples, and Milligan (2007, pp. 31-34), some of the main differences between a traditional virtual learning environment (VLE) or LMS and a PLE can be synthesized as below:

- Focus on coordinating connections between the user and services: while a VLE aims at integrating tools in a single context, PLE focuses on connecting the user with a wide range of services provided by different organizations and individuals;
- Symmetric relationship: the user becomes both consumer and producer of resources;
- Individual context: the user can choose information and resources, and reorganize them in the context;
- Open content and remix culture: the PLE is oriented towards sharing resources and using creative common licenses which allows editing, modifying, and republishing resources;
- Personal and global scope: while a VLE is linked to an organizational context, the PLE operates both at personal and global level, coordinating services and information directly related to its user and not being bounded to a particular organization;

Briefly, the PLE approach prefigures a gradual shift toward a personalized and individual-centred environment, focused on the interests of learners and their own formal and informal learning relationships.

CONCLUSION

The three e-learning models analyzed above are the most current in the e-learning formal contexts. Because of the emphasis on learning objects, LMS and course-centred vision are increasingly diminishing (Downes, 2005; Bonaiuti, 2006), it is possible to suppose that the integrated model based on collaborative and cooperative learning is a really promising matter for e-learning in the future. Even if some critical issues remain, online collaborative learning represents an interchange area between e-learning and knowledge management viewed as capitalized knowledge systems for learning communities.

In these perspectives, the new research area in informal e-learning and PLE can play a fruitful and positive role. E-learning and knowledge management can derive a significant boost from social networking attitudes and practices growing in the Web 2.0 (Pettenati & Ranieri, 2006). In this case, new challenges need to be addressed. Among these, some of the main issues are:

- The integration of formal and informal learning systems and experiences: Compared with formal learning system, social systems used in informal learning have soft boundaries. Since it entails such informal contexts, members can vary their levels of commitment and visibility, making it difficult to establish the actual boundary of a context (Wilson et al., 2007). This involves either technical problems or institutional ones.
- Management and coordination of groups and teams working in an informal learning system as a PLE. As noted by Wilson et al. (2007, p. 36), "While social software in general has been widespread popularity […], it remains unclear what mechanisms can underpin the coordination of collective actions by groups and teams within a PLE".

However, although the research on informal e-learning and PLE is just starting, we believe that the affordances of Web 2.0 technologies and their influence on online social practices (Granieri, 2005) would have a great impact on the theory and practice of e-learning in the next years.

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KEYWORDS

Content + Support Model: Indicates an e-learning model based on the separation between course content and tutorial support. The content is predefined and structured. The tutor's role is of the "pull" kind**.**

E-Learning (Electronic Learning): A Neologism created at the start of the 2000s to indicate a set of methodologies aimed at using the information and communication technologies (ICTs) in order to provide learners with learning resources and interactions free from temporal and spatial constraints. Three main solutions can be distinguished: content & support, wrap around, and integrated model. These three structures are respectively based on content, teacher's support for activities between peers and the Internet, and the collaborative learning group.

Collaborative Learning: Research has widely deepened the concept of collaborative learning. The expression "collaborative learning" can be defined broadly as an instruction method in which learners work together in small groups towards a common goal. It means that students are responsible for their own learning as well as that of the others. Thus, it promotes peer-learning and tutoring.

Formal Learning: Learning that occurs in an organized and structured environment (in a school/training centre or on the job) and is explicitly designated as learning (in terms of objectives, time or resources). Formal learning is intentional from the learner's point of view. It typically leads to certification (CEDEFOP GLOSSARY, 2000).

Informal Learning: Learning resulting from daily life activities related to work, family, or leisure. It is often referred to as experiential learning and can to a certain degree be understood as accidental learning. It is not structured in terms of learning objectives, learning time and/or learning support. Typically, it does not lead to certification. Informal learning may be intentional but in most cases, it is non-intentional (or ‘incidental’/ random) (CEDEFOP GLOSSARY, 2000).

Integrated Model: Refers to an e-learning model in which the distinction between content and support vanishes because the course content is largely stated by individual and group activity. It relies on collaborative activities and meaning negotiation. The e-tutor’s role is that of community moderator and animator.

Virtual/Online Community: Refers to a group of people that primarily interact via a computer network. The term is attributed to Howard Rheingold (1993). Even if a universal definition of this term still does not exist, it can be defined as a social network with a common interest or goal that interacts in a virtual space across time and geographical boundaries and is capable of developing personal relationships.

Wrap-Around Model: It is an e-learning mixed model consisting of partly online activities and partly predefined and structured content. It encourages a resources-based approach to learning and provides the learners with more freedom and responsibility. The tutor’s role is of the “pull” kind because only a small part of the content course is predefined.

An E-Learning Project for a Basic Mathematics Course at the University

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INTRODUCTION

This article provides an evaluation of the impact of a specific e-learning platform (www.blackboard.com) upon pass rates, in particular on the MidTerm tests pass rate of "Calculus I", a math course held at the Catholic University of Milan.

An ICT project for a basic math course was developed and introduced in 2001 at the Catholic University, Faculty of Economics. Designed for freshmen, the course currently involves as many as 1,200 students, which is quite an achievement when compared with other e-learning blended courses available at the same university. The chief objective of the course is to supplement face-to-face lessons with the online learning activities implemented inside and/or outside the traditional classroom. The innovation of this project consists not only in its technological features but also in its tracking facilities. In fact, student online activities can be tracked down and teachers are provided with continuous feedback for the same to be redesigned. In addition, students can widen their knowledge of the subject matter through additional learning materials such as interactive self-assessment tests, guided assignments, and so forth.

The course is based on four macro-areas: an information area, a content area, a grading area, and a student-to-teacher communication area.

Thanks to Blackboard tracking facilities it was possible to include in this article details on the most visited areas by students. The results of a survey conducted about students' satisfaction rating of Blackboard are also reported.

It is noteworthy to point out that the results are quite encouraging and a close correlation between "online active" students and their pass rate exists: as a matter of fact, evidence was found that students access rates and pass rates on MidTerm tests are related.

BACKGROUND

The advent of multimedia and Web technology has become the major focus of activities at the university, which is usually considered the place of excellence in terms of cultural as well as experimental trials. More specifically, the potential that these tools provide as options to improve and supplement the traditional teaching methodologies have been amply debated. Maybe, this is the result of the tremendous need for compliance to European productive standards.

In effect, if the ratio between the number of graduates and the number of university students can be regarded as a significant indicator of the university's productivity, Italy is performing poorly compared with its European counterparts. Approximately 38% of Italian students achieve a university degree after an academic career—on average—longer than that of their foreign peers.

Such a low performance of Italian universities can be undoubtedly upgraded by mixing emerging teaching patterns with traditional methods. In so doing, modern technologies can be exploited efficiently and can lead to the prevalence of new teaching styles and techniques. In Italy distance university courses are growing incredibly fast and most universities provide courses, either entirely or partially, on line. The latter are so called because they combine traditional with distance learning. According to a survey carried out by the Italian Association of Electronic Publishers (ANEE) in 2005, approximately 85% of Italian faculties were found to be delivering online courses.

These findings provide the framework for the ICT e-learning project course.

DESCRIPTION OF THE PROJECT

Calculus I is a Math basic course compulsory for some 1,200 students in the first year of a three-year degree at the Faculty of Economics of the Catholic University of Milan. As a matter of fact, a growing number of students from secondary schools face problems in understanding the course content because of their poor knowledge of the subject matter. It is a well-known fact that the relevant math exam represents a major obstacle for the students of this faculty and has not only the highest failure rate, but many dropouts and considerable delays in completing the university degree.

The Calculus I project course utilizes Web-based functions provided by a learning management system—Blackboard (Bb)—(http://blackboard.unicatt.it) that has been selected after a careful evaluation of the most popular course management platforms available. Access to the online course is granted with a password which is reserved for students enrolled in the official university course. The course is subdivided into six parallel sections because of the high number—nearly 1,200—of participants, and this subdivision is maintained in the online course, with the exception of some shared areas that serve to encourage collaboration between the groups of students and optimize teaching collaborative activities.

The course allows for either synchronous teaching—provided by the teacher mostly through a variety of media—or asynchronous teaching, in discussion forums where flexibility in terms of access time is guaranteed. Instructors, with the help of assistants, manage the online course on Bb, by making available to the students charts, material, and relevant documentation prepared by the teaching staff. In addition, virtual classroom facilities, group tests, self-assessment tests, and so forth, are also utilized.

This platform gives the instructors the possibility of monitoring the performance of their students in real time through extremely accurate access data—time of the day, day of the week, performance rates; a notable advantage over other learning management systems.

Each of the four macroareas identified within the math course on Bb, namely Information area, Content area, Grading area, and Communication area, corresponds to menu links in the left-hand column of the course home page (Figure 1).

On entry the course is displayed as is shown.

Table 1 shows the location of the areas in the menu.

Announcements. This is where course-related and other announcements are posted, including exam results, extra lessons, and newly published materials.

Figure 1. Course entry point

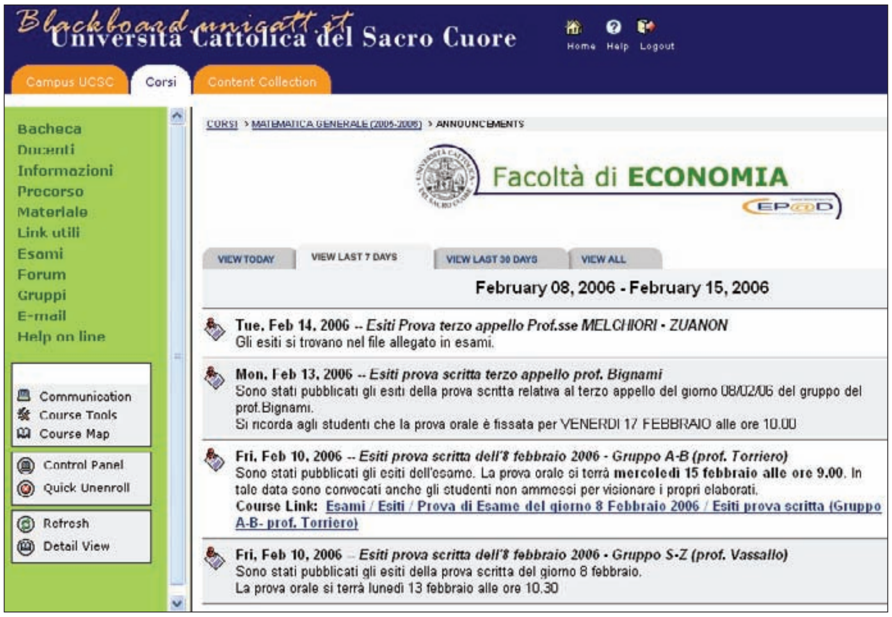


Table 1.

Information area	**Bacheca** (**Announcements**) **Docenti** (**Teaching Staff**) **Informazioni** (**Course Information**)
Content area	**Precorso** (**Math Prep Course**) **Materiale** (**Course Material**) **Link Utili** (**Links**)
Grading area	**Esami** (**Exams**) **Materiale** (**Course Material**)
Communication area	**Forum** (**Forum**) **Gruppi** (**Groups**) **E-mail** (**E-mail**)

Teachers. Under this label, the student will find addresses and other information regarding lecturers in charge of the courses.

Information. This area is comprised of:

- Exam program
- Bibliography
- Exam mode
- Exam calendar

Math Prep Course. There is a link to Teorema (http://teorema.cilea.it), another e-learning platform where students can find educational materials preparatory to Calculus I.

Course Material. This is the most important area. Each topic is split into Theory and Exercises. Teaching material—mainly slides in MS Power Point—are uploaded a few days before live lessons. This allows for a guaranteed higher performance as far as learning is concerned. The exercises proposed in this section are entirely solved and fully explained by the instructors.

Figure 2 shows a sample of the file formats made available to students. It is an example of the transparencies to be used in the classroom.

Files are usually provided in .doc, .ppt, or .pdf format.

From them, it is also possible to access self-assessment tests concerning the various teaching units. Once the test is completed, students can find out their score and receive feedback on their level of knowledge. Online access is required for these tests (Figure 3).

Alternatively, it is possible to download interactive assignments to be done off-line. Here again, at the end,

Figure 2. File format

Figure 3. Sample of a Blackboard test

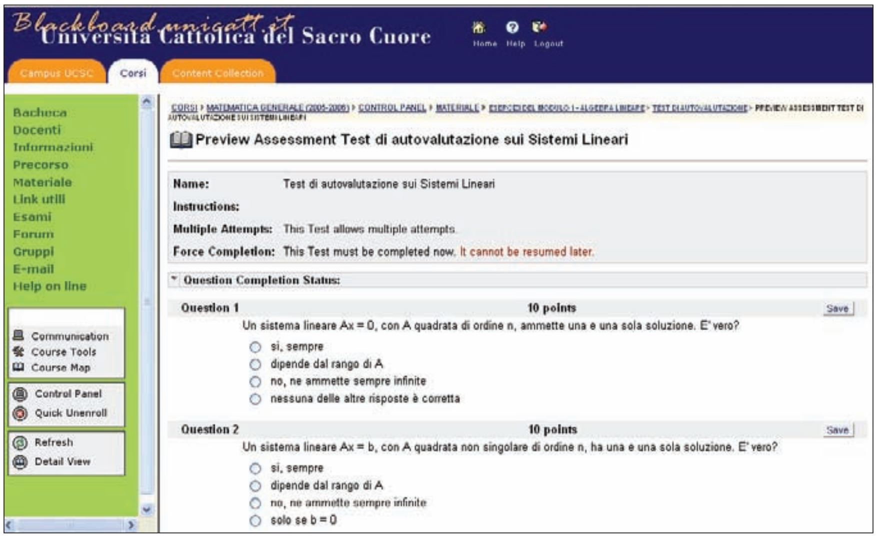


Figure 4. Calculus I discussion forum

students can find out their score and evaluate their degree of knowledge.

Useful Links. It contains the list of Websites related to the course topics for more in-depth study.

Exams. Provides access to the tests of the previous years and to the pass/fail rates of MidTerm tests and exams.

Forum. In this area (Figure 4) theme forum discussions are created, one for each of the six course-teaching units. Students can post any queries they may have and responses to them will come from another student or an instructor. This asynchronous communication tool can be combined with face-to-face (student-to-student and/or student-to-instructor) communication.

E-Mail. From this area e-mails can be sent to all the students enrolled in the same course, to instructors only, or to a single user.

Groups. Mailing list of the six student groups.

Online Help. This Web page is managed by the University Center for Permanent and Distance Education of the Università Cattolica (CEPaD) and includes technical information for students that are not familiar with the Internet and/or Blackboard.

STATISTICS AND ANALYSIS

Thanks to its tracking facilities, Blackboard allows for a feedback on the most visited areas, and identifies gaps for improvement, or removal, as well areas where enhancement is required.

For access rates to be analyzed, filtering criteria have been established as follows:

A. **Time-based filter:**

- Filter 1: from Sept. 26, 20005 to Nov. 12, 2005 (date of the first MidTerm test).
- Filter 2: from Nov. 13, 2005 to Jan. 14, 2006 (date of the second MidTerm test).

B. **Area-based filter:**

- Filter 1: on the basis of the all course areas.
- Filter 2: on the basis of the specific course content.

Access rates were first analyzed after combining the two filters. In the period of time from Sept. 26, 2005 to Nov. 12, 2005, the most visited areas are shown in Table 2.

The area with the highest access rate is **Announcements** because it is the entry point of the course.

Second—as could be expected—is the above-mentioned Content area. Visits increase in the areas where course materials and assignments can be found.

Regarding Communication areas, it has been observed that—despite a 12% access rate—the **Forum** area contained only a limited number of messages—a total of 23. This suggests poor participation by the students who access the site.

On the basis of a content-area filter only, access rates are detailed in Table 3.

As previously highlighted, the most successful area is **Course Material**, immediately followed by the **Exams link.**

Regarding the second period of time from Nov. 13, 2005 to Jan. 14, 2006, access rates are shown in Tables 4 and 5 and concern all of the course areas and the content areas respectively.

In the second time frame, an increase by approximately 7% was recorded in the access rate to Content areas, and access rate to the **Exams** area was even higher—about 17%—compared to the previous period of time. This can be ascribed to the fact that the dates of the exam session and of the second MidTerm test were

Table 2. Course access rates from Sept. 26, 2005 to Nov. 12, 2005

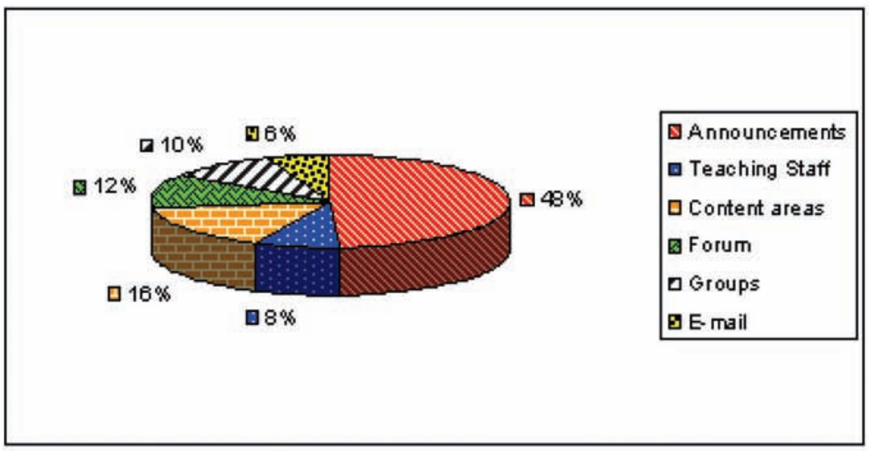
Visited Areas	Access (%)	Chart
Announcements	48%	
Teaching Staff	8%	
Content areas	16%	
Forum	12%	
Groups	10%	
E-mail	6%	
Total	100%	

Table 3. Access rate to content area from Sept. 26, 2005 to Nov. 12, 2005

Folder	Access (%)	Chart
Information	7%	
Course Material	80%	
Useful Links	0%	
Exams	8%	
1st MidTerm test Enrollments	5%	
Total	100%	

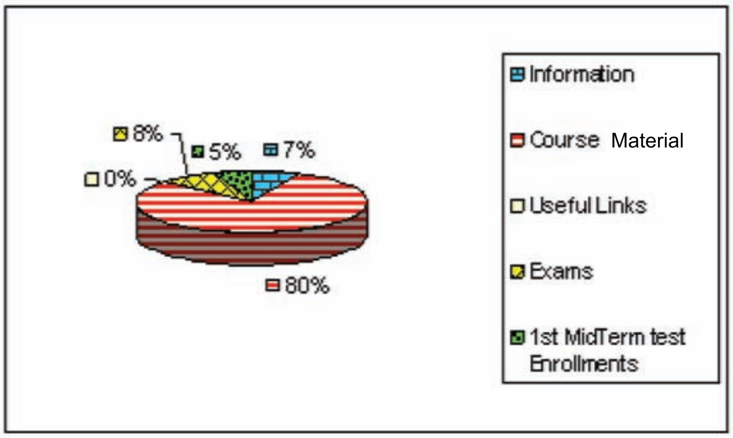


Table 4. Course access rates from Nov. 13, 2005 to Jan. 14, 2006

Visited Areas	Access (%)	Chart
Announcements	56%	
Teaching Staff	5%	
Content areas	22%	
Forum	7%	
Groups	6%	
E-mail	4%	
Total	100%	

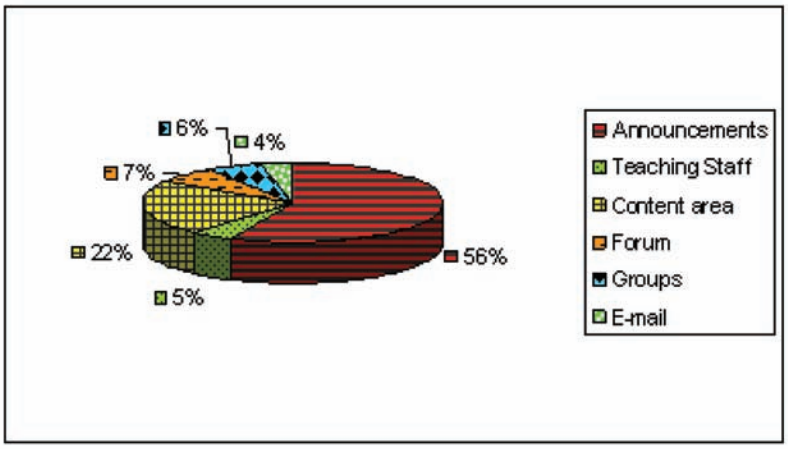
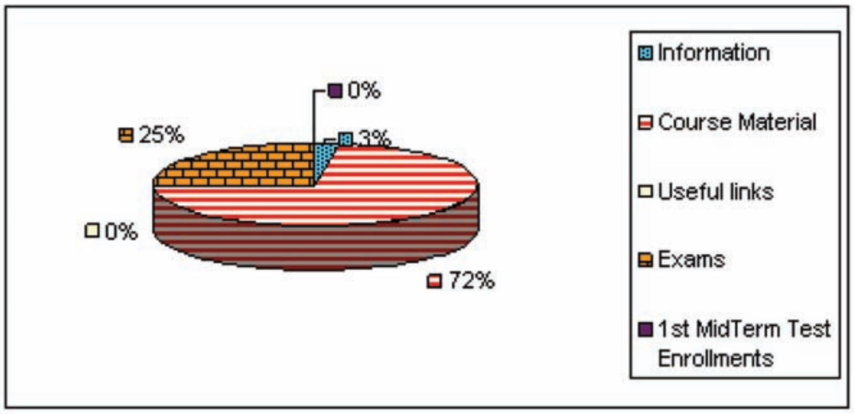


Table 5. Access rates to content area from Nov. 13, 2005 to Jan. 14, 2006

Folder	Access (%)	Chart
Information	3%	
Course Material	72%	
Useful Links	0%	
Exams	25%	
1st MidTerm Test Enrollments	0%	
Total	100%	

drawing closer. Conversely, Communication areas—either student-to-student or student-to-instructor—were found to be less accessed. The blended nature of the course may provide an explanation for that.

In order to assess the impact of Bb upon the pass rate on MidTerm tests, a group of 209 students was monitored by recording their physical presence in classrooms and their access to the online courses.

The findings are quite revealing. There is a correlation between attendance at live lessons, online participation and the pass rate on MidTerm tests.

The sample of students being monitored was categorized as follows:

1. Attending students who accessed Blackboard (AB): **92 students**
2. Not attending students who accessed Blackboard (NAB): **79 students**
3. Attending students who did not access Blackboard (ANB): **17 students**
4. Not attending students who did not access Blackboard (NANB): **21 students**

Figure 5 details the percentage rates of the students who passed both MidTerm tests according to the above categories based on the use of a traditional or virtual classroom.

As perhaps expected, the category with the highest pass rate is that of attending students who accessed Bb, followed at considerable distance by attending students who did not access Bb and finally, by not attending students who accessed Bb.

A comparison of AB with NAB showed a 49% decrease in AB pass rates. Consequently, attendance at live lessons seems to represent a crucial factor in passing MidTerm tests.

When compared to AB, the ANB profile shows a 40% reduction in the number of students who passed the exams after the two MidTerm tests. This is a smaller reduction than that observed in the previous comparison between AB and NAB.

Attendance appears to be more of a relevant factor in pass rates than online participation. This is further confirmed when comparing NAB with ANB. The category profiling ANB students is “better” than NAB.

E

Figure 5. Final results

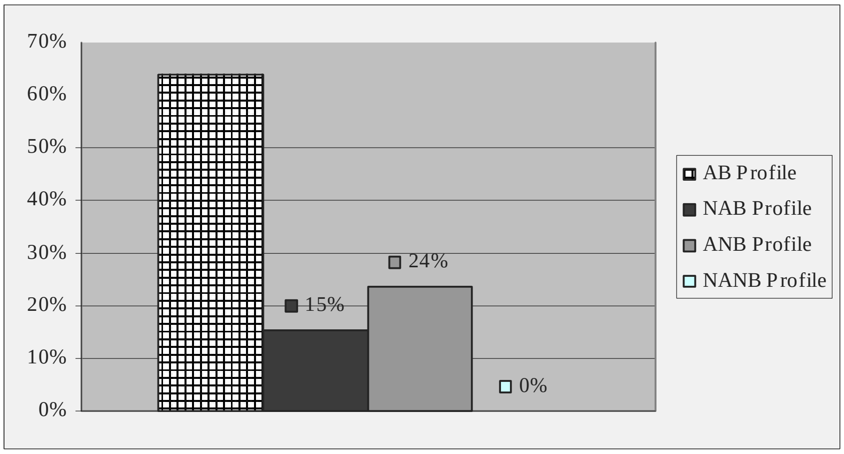
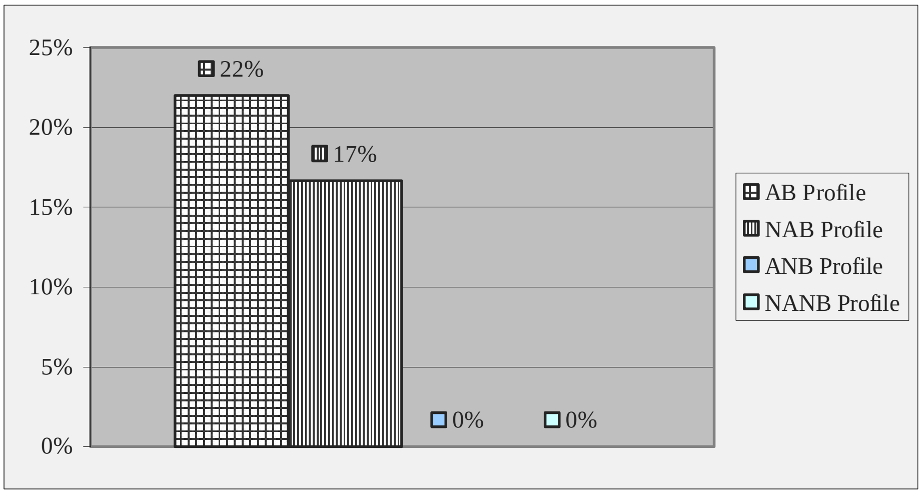


Figure 6. Grades higher than 28/30



In fact the increase at the end of the the two MidTerm tests was a mere 9%.

Compared to NANB an overall failure rate was recorded on the two MidTerm tests. This seems to show that, if lessons in traditional classrooms are lacking and the online course is not accessed, the students' ability to pass their tests is greatly reduced.

Regarding the excellence data with respect to the grading criteria, the greatest number of students who were given top grades—higher than 28/30—was recorded within the AB category.

Conversely, a change of trend was observed in the NAB and in AB categories. Despite the high number of students in the ANB category who passed the exam, no student belonging to one of those two groups was given a final grade higher than 28/30.

The NAB group has a 17% rate of grades higher than 28/30, suggesting that personal motivation to education is a crucial factor. Students who wish to pass their exams and cannot follow live lessons find Blackboard a very useful educational tool.

Table 6.

Responses	Responders (%)
+ 4 times	21,21%
3-4 times	36,36%
1-2 times	38,38%
never	3,03%
Did not respond	1,01%

Table 7.

Responses	Responders (%)
Excellent	24,24%
Good	53,54%
Sufficient	19,19%
Poor	1,01%
Did not respond	2,02%

Table 8.

Responses	Responders (%)
Excellent	25%
Good	60,61%
Sufficient	13,13%
Poor	0%
Did not respond	1%

CURRENT AND FUTURE PROSPECTS

A questionnaire was used for feedback on users' satisfaction. The results helped to identify the areas which were satisfactory, and also those areas that still require improvement or removal.

The questionnaire included:

- Assessment of the platform
- Assessment of the specific course content
- Assessment of communication area

Next is a selection of the most important questions and responses.

How often do you access Blackboard weekly? Responses are shown in Table 6.

Please indicate your Web navigation skills prior to attending this course. See Table 7.

Please indicate your Web navigation skills after attending this course. See Table 8.

In your opinion which are the most useful course areas in Blackboard? (Please rank the following areas form the most useful to the least useful). Table 9.

Data are found to be consistent with access rates. 56% of the students consider the **Course Documents** area the most useful when compared to the other areas.

This leads to the conclusion that: the course is conceived as an area for downloading materials and assignments rather than an area where extracurricular supplementary interactions between classmates and teachers can occur.

The data in Table 10 confirm this.

How much did you communicate/interact with your instructors? See Table 10.

How did you communicate with your instructors? Table 11.

The students' responses confirm the data shown in Table 2 and Table 4. Actually, the fact that the forum discussion was not used to communicate with the instructor suggests that a personal and more direct communication mode, such as a face-to-face conversation or e-mails, was preferred.

Regarding students' comments on the course content, it was found that approximately 50% of the students declared the materials were satisfactorily up-to-date and organized, and that they were instrumental for the understanding of the topics. This is consistent with the access rates that show the students' mostly prefer content areas.

In the last section of the questionnaire students were asked to express their opinions about possible areas for improvement to the current online course. Their responses are summarized below:

- Assignments should be published along with theory lessons;

Table 9.

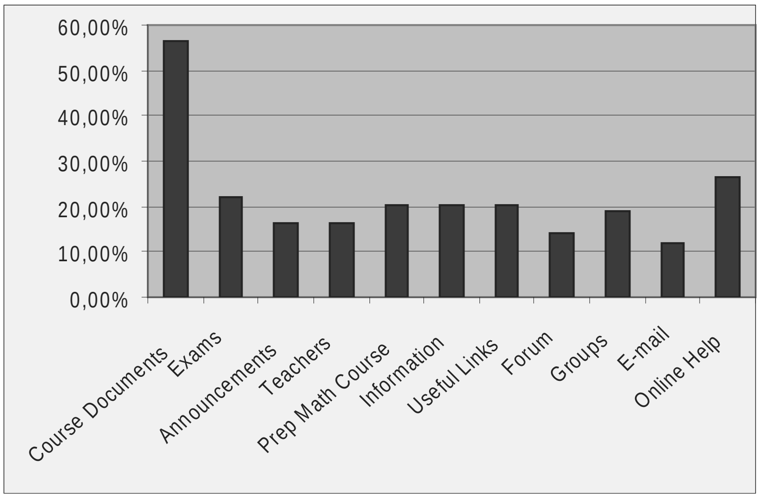
Data	Chart
1. Course Material: 56,57% 2. Exams: 22,22% 3. Announcements: 16,16% 4. Teachers: 16,16% 5. Prep Math Course: 20,20% 6. Information: 20,20% 7. Useful Links: 20,20% 8. Forum: 14,14% 9. Groups: 19,19% 10. E-mail: 12,12% 11. Online Help: 26,26%	

Table 10.

Responses	Responders (%)
Often	2,02%
Enough	20,20%
A little	51,52%
Not at all	25,25%
Did not respond	1,01%

Table 11.

Responses	Responders (%)
E-mail	44,44%
Discussion Forum	0%
Personal presence	37,37%
Telephone	0%
No communication	16,16%
Did not respond	2,02%

- A greater emphasis should be placed on the most difficult topics of the program;
- Course materials should be made available to students at the beginning of the course, as well as, during the course;
- A greater variety of keyed assignments of varying difficulty should be made available for downloading;
- Precise indications should be provided for the software required to display files and also—if possible—a folder containing the links to download the necessary players.

The results from the questionnaire and an analysis of the statistics indicate experts should attach greater importance to the objectives of experimental trials.

Quite significantly, it was found that online courses are mainly accessed for content areas. Therefore, an enhancement of the communication areas is highly recommended as these can impact on the process of generating a more collaborative learning experience by students who cannot follow live lessons in classrooms.

Regarding the online course content, learning objects design will be a top priority. In particular, strict compliance with standards of educational content interoperability and also reusability, such as the Shared Content Reference Model (SCORM. See http://www.adlnet.org/) will be implemented. In addition, course content will be redesigned for upgraded multimedia functionality—including audio/video—for the benefit of the students in the NAB category who will access the course in a self-paced learning mode.

CONCLUSION

The Calculus I project course led us to some conclusive findings. Calculus I students are enrolled in the first year of a university course and, therefore, they are not familiar with an entirely autonomous learning method. This is the reason face-to-face lessons actually support students when they study at home and the online course is found to be instrumental in their learning process. Students pass rate on MidTerm tests depends on these two factors combined concurrently with a strong motivation to study. Consequently, teachers have to take these factors in due consideration and motivate their students as much as possible. The Web-based course can make a remarkable contribution by providing enhanced instructional materials in terms of content and electronic format, up-to-date information and by encouraging their students' participation in online activities (the forum, for instance) that becomes a key to their successful learning. If these requirements are met, an efficient educational method will be achieved and a better performance will follow.

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KEY TERMS

Blended Learning: Is a learning method that combines the use of different teaching methods and communication means such as: live lessons (in the classroom or via teleconferences), self-learning (learning objects, educational texts) and collaborative learning (based on synchronous or asynchronous interaction, either live or virtual via chat-rooms, forums, and e-mail).

Calculus I: First year Economics Faculty course with a syllabus that includes linear algebra and elements of basic analysis such as, one or two variable functions, and differential and integral calculus.

Course Access Statistics: Method of tracking on-line activity of students incorporated in the e-learning software. The details provided in these access statistics allow the teacher to generate reports regarding the way the course is used and the online activity of the students (number of accesses for each student, areas most visited, average time on-line, number of daily visitors, etc.).

E-Learning Standards: A set of rules that allow for a high level of interoperability, reusability, adaptability, and durability of e-learning and learning object systems. The most common e-learning standards are ADL, AICC, IEEE, and IMS, which are designed for content interoperability of a shared metadata and statistics system.

Forum: Asynchronous communication tool that allows the user to post messages in a space shared with other users. Each post may be followed by a series of replies to the topic of the original post. Forums differ from synchronous communication tools such as chat rooms, because in forums the messages may be posted at different times by users who are not necessarily connected all at the same time.

Learning Management System: Platform application that manages the delivery of e-learning courses, and within these, the publication of contents, student registrations, online statistics, and an evaluation of knowledge acquired.

Learning Object: Modular digital resources, uniquely identified, and metatagged, that can be used to support learning (Wiley, 2000).

Mailing List: A list of e-mail addresses identified by a single name. When an e-mail message is sent to the mailing list name, it is automatically forwarded to all the addresses in the list without the need to know all members' individual e-mail addresses.

Questionnaire: Quantative analysis tool used to collect information. It consists of the categories of responses desired by the developer of the questionnaire. Depending on the format, users can respond by choosing from a predefined multiple-choice list (close-ended questionnaire), or may be allowed to respond spontaneously (open-ended questionnaire).

From E-Learning to Games-Based E-Learning

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INTRODUCTION

The emergence of the Internet has had a significant impact on higher education where we have seen e-learning evolve from a marginal form of education to a commonly accepted and increasingly popular alternative to traditional face-to-face education. While e-learning has many advantages, there have been problems identified, such as lack of contact leading to feelings of isolation; the need for a motivated, self-disciplined, and mature learner; the monotonous nature of some e-learning materials; and increased drop out rates. If e-learning has developed a reputation for being 'boring and mindless,' games have developed the reputation for being engaging and challenging. In recent years, a new form of learning has been developing, namely games-based e-learning, which builds on the successes of e-learning while providing a more stimulating and relevant learning environment for younger people who have been brought up in an environment of powerful home PCs, graphic-rich multiplayer Internet gaming, and mobile phones with ever-increasing functionality. This article will explore the concept of games-based e-learning, discuss some of its pedagogic underpinnings, and examine barriers that may limit the uptake and development of this relatively new approach to learning.

BACKGROUND

The emergence of the Internet as a new resource and communication medium has significantly changed many aspects of society, and, expectedly, it is having a similar impact on higher education (HE). Globalization has led to a blurring of national educational boundaries leading to a globalization of education, with many educational institutions searching for new markets that previously were unobtainable. The demand for higher education is significantly expanding throughout the world, a situation widely attributed to the changing nature of employment, where a job for life is no longer the norm, and to the arrival of the 'knowledge-driven society.' As a result of globalization and the push for mass higher education from both government and society, and to meet the growing needs of higher education in responding to demands for flexibility, widening participation, continuing education, and lifelong learning, institutions across the world are under pressure to integrate new technologies into teaching and learning (Connolly, Stansfield, MacArthur, & McLellen, 2007). With increased student numbers and increased pressure on HE resources, there is a drive to improve efficiency and management of the administrative elements of learning, teaching, and assessment. Virtual learning environments (VLEs) and online assessment systems integrated into other management information systems are regarded as being capable of improving efficiency and decreasing some costs.

In the last few years, we have seen e-learning evolve from a marginal form of education to a commonly accepted and increasingly popular alternative to traditional face-to-face education. Some faculty members are strong proponents of online learning and believe online courses can provide educational opportunities to learners who would otherwise have to do without. They also believe that the quality of these courses can be comparable to traditional place-bound courses. However, there are also many faculty members who are suspicious of such courses and have significant reservations about the loss of face-to-face contact between instructor and learner. While not entirely rejecting this medium, many of these faculty members use a 'blended approach' to learning (a 'middle ground').

However, e-learning has been termed 'boring and mindless' because of its current lack of interactivity (Aldrich, 2003). It can have potentially high drop-out rates, and some view it as an isolated and generally uninspiring learning experience. On the other hand, modern computer games are recognized as the industry standard for the design of engagement, interactivity, immersion, and collaboration, and give educators an insight into how e-learning can be enhanced to provide a more engaging and challenging learning experience.

In this article, we describe a teaching approach motivated by principles found in the constructivist epistemology and a particular form of constructivist learning environment based on computer games. Many researchers have expressed their hope that constructivism will lead to better educational software and better learning (for example, Jonassen, 1994). They emphasize the need for open-ended exploratory authentic learning environments in which learners can develop personally meaningful and transferable knowledge and understanding. Games-based e-learning is a constructivist learning environment in which learners are invited to actively solve problems (Leemkuil, de Jong, de Hoog, & Christoph, 2003).

E-LEARNING AND GAMES-BASED E-LEARNING

What is E-Learning?

The term *e-learning* has been used to describe an educational setting in which teaching and learning take place within an Internet-based environment (Berge & Collins, 1995) and as "the use of digital technologies and media to deliver, support and enhance teaching, learning, assessment and evaluation" (LTSN, 2003, p. 6). Some authors also distinguish between 'online learning' and 'e-learning,' where *online learning* is used to represent any class that offers its entire curriculum via the Internet, thereby allowing learners to participate regardless of geographic location (place-independent), theoretically 24 hours a day (time-independent). This is in contrast to the traditional classroom instruction, which is time and place bound, face-to-face, typically conducted in an educational setting and consisting primarily of a lecture/note-taking model and *blended learning*, which is a combination of online learning and traditional classroom instruction. The term *e-learning* can be used as a generic term to encompass both (fully) online learning and blended learning.

The research literature cites many advantages of an e-learning environment, particularly the convenience and flexibility offered by the (asynchronous) 'anytime, anywhere, any pace' and the individualized and learner focused approaches enabled by the innovative use of e-learning technologies. However, e-learning is not without its disadvantages; for example:

- Costs may initially exceed more traditional methods;
- More responsibility is placed on the learner who has to be self-disciplined and motivated (this is particularly true for e-learning that consists simply of repurposed face-to-face material, with minimal or no interactivity, which can be unengaging);
- Some learners lack access to a PC/Internet or have difficulty with the technology;
- Increased workload (Connolly et al., 2007);
- Non-involvement in the virtual community may lead to feelings of loneliness, low self-esteem, isolation, and low motivation to learn, which in turn can lead to low achievement and drop-out (Rovai, 2002);
- It has developed a reputation for being 'boring and mindless'; games have developed the reputation for being engaging and challenging (Aldrich, 2003).
- Drop-out rates tend to be higher in e-learning programs than in traditional face-to-face programs, often 10 to 20 percentage points higher (Carr, 2000).

Perhaps one of the most damaging criticisms is that some e-learning simply replicates the social organization of traditional education and that the potential benefits of e-learning (that is, of personalized and accessible learning experiences) are missed. For many years, the technology (the 'e' part of e-learning) seemed to dominate the development of e-learning, and it is only recently that there has been a wider recognition that the learning is more important: "creating technology-enhanced experiences designed to change future understanding and performance" (Squire, 2005). There is also significant debate about whether online learners perform as well as traditional face-to-face learners with some researchers suggesting that much of the media comparison studies are flawed in a variety of ways that render establishing cause-and-effect relationships or generalizations questionable (Joy & Garcia, 2000).

What is Games-Based E-Learning?

Before defining games-based e-learning, we first discuss two underlying concepts: simulations and games. Greenblat (1981) defines a *simulation* as an operating model of some system while Crookall and Saunders (1989) view a simulation as a representation of some real-world system that can also take on some aspects of reality for participants and users. Key features of simulations are that they represent real-world systems, contain rules and strategies that allow flexible and variable simulation activity to evolve, and the cost of error for participants is low, protecting them from the more severe consequences of mistakes (Garris, Ahlers, & Driskell, 2002). Simulations are often created to engage the learner in situations or events that would be too costly, difficult, or hazardous in real life, or that may be considered unethical.

Caillois (1961) defines a *game* as an activity that is voluntary and enjoyable, separate from the real world, uncertain, unproductive (in that the activity does not produce any goods of external value), and governed by rules. Crookall, Oxford, and Saunders (1987) believe that a game is not intended to represent any real-world system (unlike a simulation); rather it is 'separate from the real world.' Like simulations, games also contain rules and strategies, but the costs of losing are generally only consequential within the game world. Prensky (2001) defines the key characteristics of games as rules, goals and objectives, outcomes and feedback, conflict (and/or competition, challenge, opposition), interaction, and representation of story.

The terms 'computer game' and 'video game' were used in the past to refer to PC-based games and console-based games, respectively, but are generally now used interchangeably. Cruickshank (1980) uses the term *simulation game* as one "in which participants are provided with a simulated environment in which to play." For the purposes of this article, we will use the term 'computer game' generically to include both computer games and computer simulations for PCs, games consoles, and mobile devices.

We define *games-based e-learning* as the use of a computer games-based approach to deliver, support, and enhance teaching, learning, assessment, and evaluation and differentiate it from the more common term *games-based learning*, which tends to cover both computer and noncomputer games, such as card and board games. This is a research area that may be conceptualized as the intersection of learning theory, computer games theory and design, user interfaces, and subject matter expertise. In this conceptualization, learning theory serves as the foundation to ensure that technology does not become the dominant factor.

Why Games-Based E-Learning?

There is some debate about whether the arrival of digital technology has been a 'big discontinuity … a "singularity"—an event which changes things so fundamentally that there is absolutely no going back" and has created fundamental differences between the younger generation (*digital natives*) and the older generation (*digital immigrants*) (Prensky, 2001). Some learners exhibit a cognitive preference for certain media (Connolly et al., 2007). For example, the younger generation likes portability and is frustrated by technology that ties it to a specific location and studies show that it does not read as much as previous generations but prefers video, audio, and interactive media. Some have argued that the younger generation learns more collaboratively than previous generations and demonstrates a bias towards learning *in situ*.

Regardless of whether there is a difference between these two generations, there is a growing body of research within the theories of learning and instruction that believe computer games have highly desirable qualities worthy of further investigation. Connolly, Stansfield, McLellan, Ramsay, and Sutherland (2004) suggest that computer games build on theories of motivation, constructivism, situated learning, cognitive apprenticeship, problem-based learning, and learning by doing. By creating virtual worlds, computer games integrate "not just knowing and doing. Games bring together ways of knowing, ways of doing, ways of being, and ways of caring: the situated understandings, effective social practices, powerful identities, and shared values that make someone an expert" (Shaffer, Squire, Halverson, & Gee, 2004).

A recent survey in the UK of HE students found that computer games played an important role in the students' lives (Connolly, Boyle, Stansfield, & Hainey, 2006). Of the 85.6% of students who played computer games, they played for 7.5 hours per week on average. On average, students had been playing computer games for 11.5 years. Given that the average age of the participants was approximately 26, the average participant had been playing computer games for just under half of his/her life. Pleasure, challenge/achievement, and control came out as distinct factors in an analysis of reasons for playing computer games. Challenge was the most frequently selected reason for continuing to play games as they get increasingly difficult, and was also rated as the feature of games that might be most useful in learning in higher education. 85% of students thought that computer games are potentially useful for learning in HE.

In addition to these areas of learning and instruction, there is also a growing recognition that learning is an inherently social process, and in this section, we examine some of the social aspects of computer games that may lead to enhanced learning. *Communities of practice* (Lave & Wenger, 1991) in a professional context, and *communities of learners* in an education context (Brown & Campione, 1994) have focused on how individual development occurs within the context of the norms and activities of a community. Communities of practice are "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger, McDermott, & Snyder, 2002, p. 4). Learning occurs through participation in the practices of a community, as individuals develop ways of thinking and reframe their identities and interests in relation to the community. A desirable feature of online learning communities is that there exists varying demands and expertise at different levels of competency where participants can scaffold one another through the sharing of information and abilities (Wenger, 1998). Strong community is important as it has been shown to lead to deep learning (Chapman, Ramondt, & Smiley, 2005).

The above concepts of community and social activity do not immediately seem applicable to computer games. However, while the stereotypical perception of a gamer is someone who is young (probably male), somewhat 'nerdy,' unable to communicate, introverted, and lacking in basic social skills, this is now far from the truth. The last decade has seen the rise of multiplayer games and online (virtual) gaming communities. Not only do gamers play these games together, but in some cases, they help extend and improve the games through tools that the games developers provide or even tools that the 'community' develops. There are now countless gaming community Web sites that host discussion forums and blogs and where game reviews, community-written manuals, walkthroughs, tips, hints, FAQs, and 'cheats.'

MUDs (multi-user dungeons) and MOOs (object-oriented MUDs) are text-based online environments where users can collaborate in groups to complete quests, solve puzzles, or slay villains. These systems peaked in the 1990s and have evolved into massive multiplayer online games (MMOG) in which hundreds of thousands of players can simultaneously interact in graphically rendered immersive worlds. MMOGs generally create a persistent universe where the game continues playing regardless of whether or not anyone else is. The most popular of these games to date are World of Warcraft and Lineage, the former of which is reported to have over 10 million players worldwide. These games are not games in the traditional rules-based sense, but rather 'persistent social and material worlds, loosely structured by open-ended (fantasy) narratives, where players are largely free to do as they please' (Steinkuehler, 2004). Generally the game play mechanics are such that true mastery of the game can often only be achieved by working collaboratively with other players, which contributes to a substantial sense of community.

For example, the MMOG EverQuest lets players create and control characters, or avatars, within a fantasy world called Norrath. Characters gain skills and possessions that they can then trade with other players using the game's currency of 'platinum pieces.' However, many EverQuest players have found this process too complicated and have instead opted to sell their assets for real money though trading Web sites such as eBay. It was found that Norrath's GNP per capita is $2,266, that if Norrath was a country, it would be the seventy seventh wealthiest in the world just behind Russia, and that Norrath's virtual currency was more valuable in the U.S. than the yen (Castronova, 2001). Research in MMOGs covers disciplines as diverse as economics, politics, sociology, philosophy, and education. MMOGs such as Ultima Online, which boasts real, player-driven economies where virtual community members generate wealth, negotiate prices, accumulate capital, and form trade alliances, have emerged as important sites for economic exploration and experimentation with social systems (Bradley & Froomkin, 2003).

Such games represent an entirely new kind of social learning experience and understanding the social practices and constructivist ecologies being created around open source and massively multiplayer games will provide a glimpse into new kinds of innovation ecologies and some of the ways that meaning is created for these kids—ages 10 to 40. Perhaps our generation focused on information, but these kids focus on meaning—how does information take on meaning? (Brown, 2004)

Advantages and Disadvantages of Games-Based E-Learning

In the above discussion, we have covered a number of advantages of the use of games-based e-learning, such as increased motivation and engagement, an enhanced learning experience, and improved student achievement and student retention. The computer games approach can be useful in situations or events that would be too costly, difficult, or hazardous in real life. For example, in medical education, games-based e-learning provides risk-free training without real life consequences that might normally result in serious injury or loss of life. As Kriz (2003) points out, simulation games are mistake-friendly learning environments that allow learning by trial and error and provide immediate feedback about the consequences of decisions to aid the learning process. The instant feedback and risk-free environment invite exploration and experimentation, stimulating curiosity, discovery learning, and perseverance. It is also useful where access to human expertise or knowledge may be scarce or very expensive, providing a viable substitute that can be available at all times and organized to suit the user. Games-based e-learning is at its most powerful when it is 'personally meaningful, experimental, social, and epistemological all at the same time' (Shaffer et al., 2004, p. 3). In addition, other advantages of games-based e-learning are cited in the literature such as:

- It may encourage learners who lack interest or confidence (Klawe, 1994) and enhance their self-esteem (Dempsey, Rasmussen, & Lucassen, 1994).
- In training and educational settings, it can reduce training time and instructor load, for example, affording opportunities for drill and practice, thereby enhancing knowledge, acquisition, and retention (Ricci, 1994).
- Complex games have the potential to support cognitive processing and the development of strategic skills; they can increase users' learning and recollection capabilities and encourage greater academic, social, and computer literacy skills (Natale, 2002).
- Within an organizational setting, it can be an ideal learning environment for the training of social, management, and leadership skills in which participating staff can use their own organization as a reference system for understanding the culture, structure, and processes.
- Use of metacognition and mental models; improved strategic thinking and insight; better psychomotor skills, and development of analytical and spatial skills, iconic skills, and visual selective attention (Kirriemuir & McFarlane, 2004).

However, there are a number of disadvantages associated with games-based e-learning. The most frequently cited concerns are around the long-term effects of violence on game players, although there is no agreed consensus. For example, Provenzo (1991) claims that computer games: (a) can lead to violent, aggressive behavior; (b) employ destructive gender stereotyping; (c) promote unhealthy 'rugged individualist' attitudes, and stifle creative play. On the other hand, catharsis theory states that games playing may be a useful means of coping with, or releasing, pent-up aggression (Emes, 1997). Squire (2003) suggests recent developments in computer games design are beginning to change the ideas of a link between violent games and social maladjustment: 'thematically, video games are increasing in complexity, incorporating story, character development, and collaboration in the game design.'

Shaffer et al. (2004) make the point that most educational games have been produced in the absence of any coherent theory of learning or underlying body of research, although Prensky (2001) points out that computer games can incorporate as many as 36 important learning principles such as effective decision making, challenges, and experimentation in learning and thinking. There are concerns of a negative impact on learning as gamers may concentrate on scoring and winning rather than the actual learning objectives and concerns that games may be pitched at the wrong level of challenge and interest. There are also concerns that some games have a high learning curve and take a significant amount of time to work through, which may make them unsuitable for short modular educational systems.

Generally speaking, there is usually a high start-up cost associated with the planning, design, and development of a games-based e-learning environment. This means that while certain corporate organizations may be able to afford such costs, they may be out of reach for higher education institutions with limited budgets. Further, many games-based e-learning environments are still at the early prototype stages because of the long development times, and fully functioning games-based environments may take years to create.

THE FUTURE OF GAMES-BASED E-LEARNING

There is a significant revolution underway in approaches to pedagogy and student learning across education as a whole towards more individualized and learner focused approaches enabled by the innovative use of e-learning technologies. Within this context, we believe that interactive technologies have the potential to enhance the development of knowledge and skills. If e-learning has developed a reputation for being 'boring and mindless,' games have developed the reputation for being engaging and challenging. Interactive technologies can provide this engagement, but our students were also looking for a variety of computer-based interactions, rather than a standard 'look-and-feel' to all interactivity. It is accepted that games-based e-learning will not be for all learners, and it is accepted that there may be issues surrounding development costs.

The success of games-based e-learning is not a precise science, and there have been a dearth of empirical studies analyzing their usage. Two recent publications that provide some empirical evidence of the success of this approach are de Freitas (2007) and a special issue of the *Journal of Advanced Technology for Learning* on games-based e-learning (Connolly, 2007). As empirical evidence is limited, and, in particular, longitudinal studies are extremely scarce, further work is required on various aspects of games-based e-learning to more fully understand their potential and limitations. For example, learning through community has been demonstrated to be successful in games communities. This is an area that needs further research to identify more fully how learning takes place in these informal environments and to identify how, or even whether it is possible, to transfer this process into formal learning environments.

Given the perceived link between violence and social maladjustment and the high development costs of games-based e-learning, and given the fact that many faculty members have still not fully embraced e-learning, in the short to medium term games-based e-learning will only occupy a small section of the HE e-learning market. This has given rise to the opinion that within a HE context where resources are generally scarcer than found in the corporate world, a less sophisticated virtual games environment that is easier to adapt as well as being scaleable while at the same time being less resource intensive to develop might be a more realistic aim for the academic community to consider. A secondary route may be the development of games-based e-learning in partnership with commercial games companies.

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KEY TERMS

Computer Game: Same as Game but played on some form of computing device, such as a PC, a games-console like Playstation 2, Microsoft Xbox, or Nintendo GameCube.

Constructivism: A philosophical, epistemological, and pedagogical approach to learning, where learning is viewed as an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so.

Constructivist Learning Environment: A place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities.

E-Learning: The use of digital technologies and media to deliver, support, and enhance teaching, learning, assessment, and evaluation.

Game: An activity that is voluntary and enjoyable, separate from the real world, uncertain, unproductive (in that the activity does not produce any goods of external value) and governed by rules.

Games-Based E-Learning: The use of a computer games-based approach to deliver, support, and enhance teaching, learning, assessment, and evaluation.

Games-Based Learning: The use of computer and noncomputer games, such as card and board games, to deliver, support, and enhance teaching, learning, assessment, and evaluation.

Online Learning: Any class that offers its entire curriculum via the Internet thereby allowing learners to participate regardless of geographic location (place-independent), theoretically 24 hours a day (time-independent).

Simulation: A representation of some real-world system that can also take on some aspects of reality for participants and users. Key features of simulations are that they represent real-world systems, contain rules and strategies that allow flexible and variable simulation activity to evolve, and the cost of error for participants is low, protecting them from the more severe consequences of mistakes.

Simulation Game: A game in which participants are provided with a simulated environment in which to play.

From E-Learning to T-Learning

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INTRODUCTION

The introduction of interactive television offers new potentialities to the television medium with the possibility of including e-commerce, programs on demand, games, and, last but not least, educational programs. Digital television will allow forms of lifelong learning to disadvantaged sectors of the population, namely those potential learners that have no possibility to improve their own knowledge caused by problems such as lack of free time due to working hours, family care, and so forth. Much of the interactive potentiality of this new medium will depend on the possibility of having a back-channel, connecting television to the Internet. A back-channel would allow the user to store choices, preferences, progress in learning units, and so forth, in the memory. In other words, there is the possibility of customizing the programs offered and the interface according to user preferences. The potentialities of this new medium are numerous, and it is necessary to explore, experiment with, and facilitate the new methods of available interaction. Every great technological change has also meant a change in perspective and mindset. What generally happens in the early stages of the utilization of new technological solutions is that the new tools available continue to be used while adopting an outdated mentality. It is necessary to propose a pedagogical model for the learning programs offered by new technology.

BACKGROUND

Learning Online

The Internet is shattering traditional teaching and learning styles. Most education today is information transfer from the teacher's mind to those of learners. This traditional delivery system is only one way to learn. What the Internet is doing is splitting the traditional teaching method into two parts: cognitive learning, which can be accomplished with online learning, and affective learning, which can be carried out in a small-group discussion setting (Draves, 2000). E-learning has evolved from the first static Web sites to systems where the focus is now on content personalization. Researchers attempt to adapt didactic material to students' unique learning styles, trying to meet individual student needs. E-learning can be considered more a social than a technological phenomenon, since the main issue in e-learning is learning, and not the technological media employed (Santos, Vale, & Meloni, 2006).

There are several aspects that can make online learning better than classroom learning:

- A learner can learn during his optimal learning time during the day
- A learner can learn at his own speed
- A learner can focus on specific content areas
- A learner can test himself daily
- A learner can interact more with the teacher.
- Online learning is less expensive and thus more accessible
- One can learn from the foremost authorities and experts

Interaction between the participants and teacher, as well as interaction among the participants themselves, is at the heart of online learning.

NEW MEDIUM, NEW LEARNING

A few public service educational broadcasters and commercial broadcasters have started or are about to offer learning programs due to the increased capacity made available by digital TV. In some instances, it may not be appropriate for educational providers to offer interactive services via TV at this stage, as interactivity will best be achieved via the Internet. For example, a university-level course may involve broadcasting a TV program, but as most people taking a university course will have a computer for writing assignments, it is probably easier to offer interactivity via the Internet

(PJB Associates, 2004). However, where there is need to target people who would not normally participate in further education, interactivity becomes very important in transforming them from passive viewers to active participants. A new medium will require a new way of learning, as the learning setting, users, time, and goals will be vastly different from those of e-learning.

Interactive Television

Television is a medium central to people's everyday lives. It has developed its own grammar and structure, and the audience has established specific, well-defined interaction patterns unique to this medium. However, a literature review has revealed that the approach followed by most scientific publications is principally PC-centric and usually implicitly focused on the work environment (Chorianopoulos, 2003). New interactive television makes two cultures converge, two cultures that have thus far traveled on separate tracks: television and the Internet. On the one hand, we have television, with its entertainment characteristics, its ability to tell stories, to offer richly visual programs; on the other hand, we have the Internet with its democratic culture allowing diffuse participation by community members with the important role accorded the individual in choosing what to access.

Some learning forms of ICT (information communication technology), in particular those relative to edutainment, will greatly influence the programs that will be produced for interactive television. And if forms of e-learning are planned for the new medium, they should be redesigned for the new technology. A new technological medium requires new visions and utilizations, new ways of learning. The interface used by television is very different from that used by the Internet. Table 1 highlights some major differences.

Due to these differences, it is not desirable to transfer the same formats offered in e-learning to digital television. In general, however, the attitude towards interactive television as demonstrated in the USA are only moderately encouraging for educators, as it seems those exclusively using television do not necessarily find many services (other than games) attractive. Those who find the other services attractive are computer users, and it would then beg the question of why we should invest in another technology (for work or training) when users probably already have access to the Internet (Berry, Kelso, & Lamshed, 2000).

At the start, there was some skepticism about interactive educational television. There was a feeling that work completed to date had consisted of reusing old computer-based learning techniques unimaginatively in a new interactive medium (Luckin, Coultas, Underwood, du Boulay, Mateer, Mudge, et al., 2003). So far, different methods of program enhancement through interactive television have been experimented. Program enhancement can take a number of forms: picture only, picture with prompts for additional information, picture with overlaid information, information with inserted picture, and information only (Berry et al., 2000).

Table 1.

Features	***T-Learning***	***E-Learning***
Data processing ability	Lower data processing capability	Huge data processing and storage capability
Screen resolution	Lower resolution of presentation devices	High resolution of presentation devices
Interactivity	Reduced interaction opportunities, due to the sole use of a remote for interaction	Great interaction opportunities, using keyboard, mouse, and other devices
Distance from the screen	Elements displayed on the screen must be readable from a distance	The display is generally viewed at a short distance, allowing the use of even very small fonts and visual elements
Utilization	Traditional passive utilization of equipment	Traditional active utilization of equipment

a. **Video with prompts for additional information:** A "button" is provided on the screen that when selected by remote control will link to further program information. This additional material is broadcast simultaneously in real time with the video. The additional information may be text, images, or even another video.
This information is not retrievable when the broadcast is over.
b. **Video with overlaid information:** In this case, additional information is screened at the same time as the video broadcast and laid over the picture. However, the text needs to be fairly large, colorful, and limited in quantity because the screen is viewed at a distance of 2 meters or more. Consequently, concise information is effective. This function may be useful when a specific point or issue needs to be highlighted at the same time as the video transmission.
c. **Information with inserted video:** In this case, text needs to be sufficiently large for clear reading at a distance of 2-3 meters. This function is effective when there is a large amount of content to be presented.
d. **Information only:** This function is currently broadcast as teletext on analog television.

Among the programs that have established a standard as far as interactive television is concerned are two natural science BBC productions: "Walking with Beasts" and "Blue Planet." Users can choose whether to watch the additional text or extra video documents, and they can also choose among commentaries focusing on various scientific aspects. The additional material is made available for a span of time longer than that of the broadcast itself. Another historical program by the BBC was "Pyramids." For every episode, online quizzes and competitions based on solving mysteries were proposed. For younger audiences, the BBC has produced elementary interactive games, like those associated with the programs "Bob the Builder" and "Teletubbies." None of these programs was planned as a deliberate form of learning, but rather as a reaction to the broadcast program (*reactive learning*).

One of the television networks with a consolidated tradition in digital programs is Chaos Media Networks (http://www.chaosmedianetworks.com/), which offers daily a series of interactive programs according to the preferences of different target users. The programs offered Chaos Media Networks are examples of different forms that digital television might take, namely:

- Linear broadcasts, from those scheduled daily to programs on demand.
- During each program, users can ask questions using the remote and receive answers in the form of 30-90 second video clips providing a quick presentation of the topic on which the questions were based.
- Nonlinear interactivity, by means of a menu. The menu offers different segments of programs according to user or target audience interests. For example, in the case of a language program, only the in-depth parts at the user's level will be shown on the screen.
- Episodic programs, mini-series tailored to spectator interests.
- In interrupted modality, programs that offer the spectator, with no previous notice, a long or short program (for example a quiz).
- Collaborative programs, which may have different spectators participating at the same time (e.g., a debate on local problems).

MAIN FOCUS OF THE ARTICLE

TV has perhaps most often been seen as an entertainment medium with a complex identity. Its use moves along an axis ranging from passivity to escape and entertainment, and finally, in the best of cases, to a type of engagement (Ling & Thrane, 2002). Possible forms of learning fall into two main areas:

- Formal learning
- Informal learning

The main difference between the two is that informal learning typically lacks the administrative attributes of formal learning, such as external evaluation, the awarding of credits, a prescribed learning framework, and so on (Smith, 1999).

According to Masthoff and Pemberton (2003), the potential of T-Learning may best be realized by concentrating on informal rather than formal provisions. Eraut (2000) also suggests that we need to explore the full range of learning processes or modes falling within the domain of "nonformal learning." Eraut creates a continuum with, at one end, *implicit learning*—"the acquisition of knowledge independently of conscious attempts to learn and the absence of explicit knowledge about what was learned." At the other end is *deliberative learning,* where time is specifically set aside for learning. Between the two lies *reactive learning*, when learning is explicit but takes place nearly spontaneously and in response to recent, current, or imminent situations but without any time being set aside for it.

In the case of t-learning, we can think of forms of reactive learning connected with the viewing of normal television programs. Before, during, and after the program, through the apparition of in-depth icons, users are allowed to move to short learning paths that are absorbing and exciting. Because they are chosen on the spot, these programs must necessarily be complete in themselves, condensed, and modular at varying levels. The user must always have the possibility of choosing, according to her momentary needs, the level and in-depth section and whether or not to utilize them, along with the modality of choice.

In designing t-learning programs, particular attention should be paid to the TV audience. A definition of the interactive television audience is a rather complex problem. Educational programs on digital television need to adapt to viewer interests and viewing habits. The difficulty in defining viewer learning conditions is due to the fact that watching TV is basically a social phenomenon involving groups of viewers at the same time. More formal ways of learning do not fall naturally into how we normally use television, like watching TV while we are engaged in other activities, zapping from one channel to another or watching TV with other people. After all, television is considered a medium oriented towards entertainment rather than one promoting activities.

From all this, it follows that the aim of t-learning should be above all to offer informal learning programs rather than formal ones. More formalized learning programs will be offered to users that are more motivated and more used to e-learning interaction, targeted users within institutions such as schools or universities. However, the majority of learning programs should be based on so-called "lazy interactivity." Viewers will be asked to cast their vote on a current topic, to take part in a survey, a quiz, on their own or together with other viewers. The habit of watching quiz shows could be the starting point for promoting other forms of learning. The back-channel will allow users to have immediate feedback to their answers.

In informal learning, learning objectives are defined by the user: it is the user who decides what to watch, for how long, and up to what point. It is accordingly necessary for t-learning educational programs aimed at informal learning to help users in their choices, first presenting all the objectives that users might expect to achieve with the content offered, along with their forms of presentation. It has already been stated that traditional forms of assessment, present in more formal formats where it is required to certify the level of knowledge and ability achieved, cannot be proposed in informal learning. This is due to the fact that the user is free to skip around and watch the parts that momentarily interest him the most. Nonetheless, quick forms of assessment of the competencies acquired might be conceived to be administered after short learning sequences, as well as evaluation methods regarding progress satisfaction levels, either through the number of users or user satisfaction levels, to be determined by means of short questionnaires.

One of the most meaningful limits of informal learning is the short attention span. This is due to the fact that although there might be the desire to achieve the objectives established, at the same time program viewing is bound to be interrupted, as there are other things to do at the same time (children, need to socialize with other people in the same room, etc.). Another aspect connected with the limited time available is that instead of looking for specialized services on the topic among those offered, an informal user is likely to choose the first available source. One way to increase attention span is to involve the user in a story or ask her to take part in a simulation (Driscoll & Carliner, 2005).

Electronic games are generally seen as pastimes, but they might have useful educational applications. As far as possible, games should be connected to both formal and informal in-depth paths. A racing car simulation game could have links to:

a. A quick test consisting of 10 true/false or multiple choice questions
b. A short animation or educational simulation

Both of these examples focus on how a car engine works.

FUTURE TRENDS

Market research on the first digital television programs have highlighted how supplementary channels are generally appreciated much more than interactive functions within the programs themselves. Games were the most frequently requested service. The main reason why consumers do not use interactive services has been identified in a lack of familiarity with the medium and with educational training. It is expected that viewers will access interactive services much more frequently as they become more familiar with the technological tools available.

An important feature of interactive television will be to favor forms of lifelong learning. This new television should not only encourage the participation of those already involved in forms of self-study, but also encourage broader participation in bettering their education after the end of formal academic training. Considering that, for a variety of reasons, the utilization of computers does not involve the whole population, television, with its almost universal presence in every home, might be an alternative solution to face the emerging digital divide and offer opportunities for educating population groups not involved in lifelong learning. The success of this solution will depend on finding solutions and tools that the targeted population is familiar with and can use in their own homes.

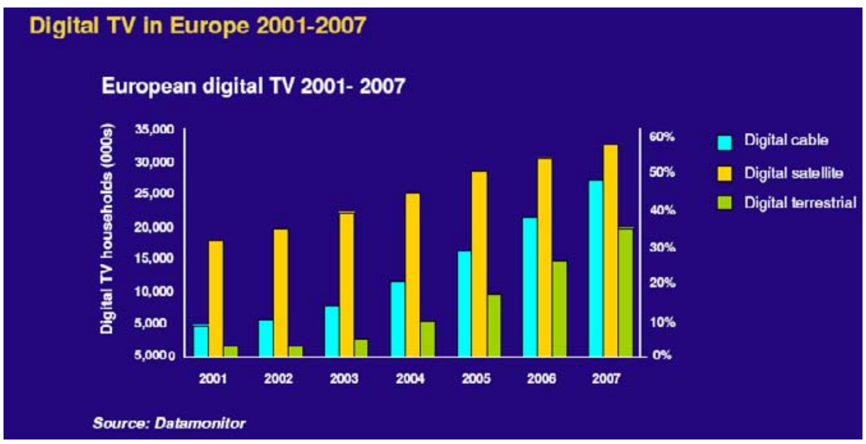
CONCLUSION

In the emerging era of lifelong learning, learning will take place in a wide variety of contexts and locations in which informal and nonformal learning will be as important as formal learning (Bates, 2003). There is some evidence to suggest that nearly one-third of adults say they have not participated in any formal learning since leaving compulsory schooling. Lifelong learning initiatives should therefore not only encourage increased participation of those already engaged in learning, but encourage wider participation of those not actively involved in it.

Approximately 99% of households have a TV as compared to around 50% of households with an Internet-enabled computer. Research suggests that Internet-enabled computers are unlikely to reach more than 60% of households and that digital TV will increasingly become the dominant means for accessing structured information and interactive services. Most children spend at least two and a half hours per day watching TV. In many homes, the television is on when they come home from school and is still on when they go to bed.

Working class children are far more likely to have their own television (and spend more time watching it), while they are far less likely to have access to a PC. The potential for education via television is clear. Interactive television could bring some form of instruction into people's living rooms and children's bedrooms. For instruction to be effective, the system (television in this case) needs to adapt its broadcasts to the interests,

Figure 1.



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capabilities, and knowledge of the individual student. In the case of television, this is even more important than in a classroom, as television competes with other entertainment forms (Masthoff, 2002). This means looking towards solutions and devices that people are familiar with and feel comfortable using, either in their own homes or on the move. Opportunities for informal learning will also increasingly be a means to encourage and draw people into active, engaged learning that might lead to learning of a more formal type.

Television is a familiar and reliable consumer device with around 95-99% penetration in European households. It is also perceived as a learning tool. However, in its more traditional role, it has tended to be used in a passive viewing mode. The problem is how television's educational potentialities can be exploited to the fullest. Based on the nature and habits of television audiences, t-learning should be most of all designed so as to engage viewers in forms of reactive learning, that is, forms of explicit learning that take place spontaneously in answer to recent or current situations without any time being specifically set aside for it.

Along with reactive learning, a major share of users' preferences will be for games. What is essential is to shift from a PC-centric vision of learning to one based on the limits and potentialities of the new medium. Television is present in the majority of homes in most countries and, as e-learning is backed by years of research and improvements, the main factor in the success of t-learning is to continue e-learning research activities, to determine how the Internet and this new media form may converge. Further research is also needed to explore this medium through large-scale trials in order to better understand the sociological, socioeconomic, cultural, and motivational factors enabling individuals to move from participating in informal learning to more active and engaged formalized learning in their own homes (Bates, 2003).

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KEY TERMS

Back-Channel: A means of communication between users and content providers. A simple type of back-channel is an Internet connection using a modem. Viewers and listeners can use a back-channel to provide feedback, request additional information, and purchase goods and services.

Edutainment: Edutainment is a form of entertainment designed to educate as well as to amuse. Edutainment typically seeks to instruct its audience by embedding lessons in some familiar form of entertainment: television programs, computer and video games, multimedia software, and so forth. Most often, edutainment seeks either to tutor in one or more specific subjects or to change behavior by engendering specific sociocultural attitudes.

Formal Learning: Learning taking place within an organized, structured context like formal education or company training, which is intentional from the learner's perspective and may lead to formal recognition (diploma, certificate).

Implicit Learning: The acquisition of knowledge independently of conscious attempts to learn and the absence of explicit knowledge about what was learned.

Informal Learning: Learning resulting from daily activities, often related to experiential learning and often considered accidental learning; it may be intentional but is generally mostly non-intentional from the learner's point of view.

Interactive Television: Interactive television describes technology allowing viewers to interact with television content while viewing. To be truly interactive, the viewer must be able to alter the viewing experience or return information to the broadcaster. This "back channel" can be by telephone, mobile SMS (text messages), or cable.

Lazy Interactivity: The ability of users to flick directly from a TV program to datacasting services as opposed to going from one system into another or using a relatively complex medium such as the Internet.

Lifelong Learning: In a European Commission memorandum, the definition is "all purposeful learning activity undertaken on an ongoing basis with the aim of improving knowledge, skills, and competences." A broader definition would also include lifelong learning as a means of reintegrating the alienated back into society and promoting active citizenship. It should also embrace the possibilities of using lifelong learning to promote people's personal development and value as human beings. A broader definition would then stress lifelong learning as learning over the entire lifespan, including all learning activity, whether formal or informal with the aim of improving knowledge, skills, and promoting personal fulfillment.

Nonformal Learning: Learning embedded in planned activities not explicitly designed as learning but containing an important learning element, intentional from the learner's point of view.

Reactive Learning: A form of learning that is explicit but takes place almost spontaneously and in response to recent, current, or imminent situations but without any time being specifically set aside for it.

T-Learning: T-Learning refers to the offering of e-learning services using digital TV technologies. T-learning, a shorthand meaning for TV-based interactive learning, is about having interactive access to video-rich learning materials primarily within the home by means of a television or a device more like a TV than a personal computer. T-learning can be seen as the convergence of two technologies: television and the computer.

Is Electronic Knowledge a Plural Thought?

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INTRODUCTION

With the third millennium a new and attractive scenario has opened up, giving voice to an old face of culture: *knowledge*. Its "new" identity—holistic, multidimensional, and ecosystemic—was highlighted by the European Union in 2000 at the Lisbon conference.

In the 21st century there is a star carrying out on its tail these words: welcome to the knowledge society.

Knowledge is an immaterial good needed by any nation, because it's like a bank account that any complex and changing society needs to have. It's a capital with three faces: economic, social and human (Frabboni, 2006).

a. As an economic resource, knowledge promotes a mass-school, a school for everybody: the competitiveness and reliability of a productive system are based on schooling and on the "well-made heads" of younger generations,
b. As a social resource it promotes democracy, because knowledge provides all citizens with the necessary alphabets to create a widespread social cohesion; therefore education must be spread during all the seasons of life, from childhood to old age,
c. As a human resource it helps the person-subject to move away from the devastating mass-subject. A school of knowledge and of values (i.e., of mind and heart) will have to invest on a person that is nonduplicable, noneasily influenced, and nonuseful; with his or her eyes open on dreams, utopias, and enchantment. School has the task of forming a plural mind and an ethic of solidarity.

But what is the meaning of this macroword and what are its visible signs which can help us to recognize knowledge? And what is usually meant in Europe by knowledge era? Is this the best way to form citizens with a plural mind and an ethic of solidarity, from a pedagogical point of view? We have many doubts in giving a positive answer to these questions (Frabboni & Pinto Minerva, 2001).

First of all, we would like to highlight the cry of alarm recently raised from the European Ministries of Education in Lisbon. In this society of *immaterial economy*—informatics, telematics, robotics—it is important to promptly globalize literacy. This is the only way to ensure that everybody has a black box (i.e., a cognitive machine) able to register and use the *online* languages scattered in the global village of digital information. A *non-stop* circulation of languages on the Net (electronic) overwhelms the minds of the people living in this ocean of media. We need "life rafts" equipped with informatics compasses, to overcome the risk either of being driven out of the modern digital-based social communication due to illiteracy, or of being overwhelmed and swallowed by these esoteric and sometimes cryptic codes.

We agree with European Ministries of Education, but with some reservations (Frabboni, 2003).

We agree with the European Union, when it states that people living in the 21st century cannot risk computer illiteracy, otherwise they would be excluded from the most important parts of society (economic, social, cultural and scientific). But we have a pedagogical confutation to this statement: a singular and totalizing vision of communication and knowledge as only digital is just as dangerous as illiteracy; it is especially true when the European Report assigns to information technology the task of redesigning *culture* (Frabboni, 2005).

The Lisbon Report identifies the education equipment of the future with the "microset" of knowledge, which requires a monocognitive function. This is the ability of storing (assimilating), and selecting (by eliminating and/or memorizing) the floating "knowledge" one can find in the Internet. This knowledge is basically "exogenous", that means that it is of social utility or use by the people living in modern information society.

In the Lisbon Report there is no reference to the "macroset" of knowledge, which requires a meta-cognitive function, considered as an "endogenous function" of nonimmediate social utility or use. We are talking about a threefold tool: *hermeneutics* (the ability to understand and interpret knowledge), *investigation* (the ability to discover and generate knowledge) and *heuristics* (the ability to invent and create "new" knowledge). A widespread higher education—mono and meta-cognitive—is needed, if we want our future generations to be able to navigate in the modern sea, full of mass and personal media, and to reach the shores of human resource called "singularity" of the *subject-person*: noncliccable, not easily influenced and nonuseful.

In our opinion, the macroset of knowledge is fundamental and we need to defend it as much as we can. It is the logical and formal command of endogenous nature, able to keep watch of *communication*, which is more and more hostage of a symbolic language (online and iconic). A prefabricated *symbolic-world*: frozen, metallic, without any soul.

Men and women risk to lose their direct contact with reality. *Image* and the *informatics code* (mail or chat) could exclude both "oral" and "body" language, and this could lead to the repression of those languages in everyday life: yet the formative potential of languages lies exactly in the plurality of their codes and functions.

Many languages are therefore at risk in their functions of *social communication* (talking with others), *cognitive communication* (thinking and representing the world in symbols), and *expressive communication* (expressing feelings and personal emotions).

The multiple intelligences suggested by Gardner are therefore fundamental for the people living in a semiological century. Men and women need to be able to grasp and connect together by using all the scattered links in this gigantic cognitive chain. But this will not happen if European politics makers will decide to abandon their citizens—dazed and helpless—in a world full of ambivalent signs, often difficult to understand and sometimes impossible to be used for communicating.

A self-service market of cultural goods seems to us a boundless mass-media and an electronic sea, with a huge "long-wave" able to wrap the consumer up—the children as well as the old people—in a nonstop cloud (24 hours a day), full of iconic and computerized alphabets. This "cloud" is currently in the middle of a fierce battle between those who avoid technology because of its cognitive toxicity (a vehicle of frozen knowledge to be warmed up and eaten by consumers), and those who greet it as bearer of a benefic rain of widespread culture (because of the easy access to it).

The truth is that the technological cloud is already present in our life and everybody can feel it. The only thing we can do is to regulate, qualify, and evenly share out this abundant "rain", but we definitely have to deal with it.

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KEYWORDS

Knowledge: An immaterial good needed by any complex and changing society. It's a capital with three faces: economic, social, and human.

Metacognitive Function: It is an "endogenous" ability. It is a threefold tool: *hermeneutic* (to understand and interpret knowledge), *investigative* (to discover and generate knowledge), and *heuristic* (to create "new" knowledge).

Monocognitive Function: It is the ability of storing (assimilating), and selecting (by eliminating and/or memorizing) the floating "knowledge" found in the Internet which is basically "exogenous".

Electronic Loyalty Programs Comparative Survey

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INTRODUCTION

Loyalty is defined as the repeated satisfaction of a customer with purchases of products from a specific firm or brand. Firms have been developing customer loyalty programs because it is generally less expensive for firms to retain existing customers than to attract new ones (Reichheld & Schefter, 2000). Although the correlation between customer loyalty and long-run firm profitability is under discussion, there is a consensus on positive effects of customer loyalty programs on firm sales (Reinartz & Kumar, 2002). Loyalty programs are also attractive for customers since they receive special offers or discounts.

The notion of loyalty on the Internet, coined as electronic loyalty (e-loyalty), is a relatively new concept. However, because of their potential to increase sales and reduce online customer retention costs, e-loyalty programs have received much attention from both businesses and academic researchers. In what follows, we first summarize major theoretical results and empirical evidence on customer loyalty in the literature. We then analyze different types of popular e-loyalty programs on the Internet.

BACKGROUND

It is found that firms can create loyal customers in traditional markets by exploiting or artificially generating the so-called consumer switching costs (Beggs & Klemperer, 1992; Chen, 1997; Kim, Shi & Srinivasan, 2001; Klemperer, 1987a; Klemperer, 1987b). Switching costs may arise from a variety of factors such as the nature of the product (learning and adaptation costs), consumer characteristics (risk-aversion), or deliberate strategies followed by firms (frequent-usage points or cash-back rewards). Klemperer (1987a) suggests that the noncooperative equilibrium in an oligopoly with switching costs may be the same as the collusive outcome in an otherwise identical market without switching costs. Padilla (1992) finds that switching costs make overall competition less severe and may lead to local monopoly power. Beggs and Klemperer (1992) study the evolution of duopolists' prices and market shares in an infinite-period market with consumer switching costs. They show that firms' prices and profits are higher if switching costs are present in the market. In a recent paper by Kim, Shi, and Srinivasan (2004), loyalty programs are examined in the context of capacity management. They find that loyalty programs enable firms to better adjust their available capacities in response to the actual level of market demand.

The concept of e-loyalty may differ from the conventional notion of loyalty in traditional markets. Among the factors that play important roles in building e-loyalty are the prior experiences of customers with an e-commerce website, information content of the Website, the time it takes to shop, the ease and security of online transactions, and the price advantage (Devaraj, Fan, & Kohli, 2003). It is easier for e-commerce companies to track customer behavior through the use of online surveillance technologies and customize products and services for individual needs. However, reinforcing e-loyalty appears to be vital due to consumer wariness about electronic shopping, which leads to high customer acquisition costs and low retention rates.

Recent empirical research indeed supports the existence of e-loyalty in e-commerce markets. For example, by analyzing data from online price comparison software, called "shopbots", Smith and Brynjolfsson (2001) find that customers are willing to pay premium prices for books from online retailers they purchased before. Chen and Hitt (2002) also find parallel results by studying online brokerage industry. Johnson, Moe, Fader, Bellman, and Lohse (2004) report that almost 70% of online CD and book shoppers are loyal to only one site and consumers tend to search fewer sites as they become more experienced with online shopping. Using a survey data, Devaraj, Fan & Kohli (2003) find that customer loyalty toward online stores is significantly higher than their loyalty toward conventional brick-and-mortar stores. They argue that the state-of-the-art Web technologies implemented by e-commerce firms are among the major factors reinforcing e-loyalty more than their traditional counterparts.

A SURVEY OF E-LOYALTY PROGRAMS

E-Loyalty Programs Based on Cash-Back Rewards and Frequent-Usage Points

The most common forms of e-loyalty programs today are those utilizing cash-back rewards or frequent-usage points. In the *ClickRewards.com* program, for example, customers can earn *ClickMiles* for every qualified purchase they made from the Website. *ClickMiles* are redeemable for miles on any of the ten major U.S airlines or for other rewards. Another shopping portal, *Ebates.com*, pays customers up to 25% cash-back on qualified purchases. To cover the operational cost of the program, *Ebates.com* charges companies selling products on its portal. *Spree.com* and *CashbackOutlet.com* also offer customers cash-back rewards on qualified purchases. Customers can also receive additional cash-back by referring new shoppers to the Website. Finally, the *GreaterGood.com* and *iGive.com* are both philanthropy portals where customers can donate up to 26 percent of their purchase amount to a charity they wish to support.

Affiliate marketing is another type of lucrative e-loyalty program on the Internet. It is a new method of online advertising that allows Websites to share traffic and revenue using banner and text advertisements. Firms selling goods and services online pay commissions to affiliate Websites for sending traffic to their site, which is tracked by a special software application. Firms pay affiliates according to several schemes such as cost per sale, cost per lead, cost per click, or cost per impression. Affiliate marketing creates new opportunities for online firms to increase sales, for affiliates to earn revenue from their sites, and for consumers to find the products and services on the Internet easily. Among the companies specialized in online affiliate marketing are *LinkShare.com*, *Performics.com*, *CommissionJunction.com*, and *eLoyalty.com*. With over 10 million partnerships around the world, *LinkShare.com* manages the largest affiliate marketing network on the Internet. It also provides merchant firms with services to create and manage their own affiliate marketing programs. Both *Performics.com* and *CommissionJunction.com* offer their customer firms performance-based affiliate marketing services supported by e-mail marketing programs. Lastly, *eLoyalty.com* offers e-commerce firms consulting services related to affiliate and targeted marketing to reinforce e-loyalty.

Comparison of Cash-Back Rewards and Equity-Based E-Loyalty Programs

Cash-back rewards are the oldest type of loyalty programs, in which customers are offered either instant price discounts or rebate checks. E-loyalty programs based on cash-back rewards can, in general, increase firm sales but may not be able to promote firm-specific loyalty since customers are not obligated to go back to the same firm after an initial purchase. The rewards gained by customers through these programs may be spent on the products of any participating firm, leading to a post-opportunistic behavior and lower levels of firm-specific customer loyalty (Figueiredo, 2000).

In equity-based e-loyalty programs, on the other hand, customers are offered a fraction of merchant firm's equity for each purchase. Customers become fractional owners of the merchant firm through the collection of the firm's equity after each purchase. The amount of equity offered to customers is very small—usually around 1% of the unit share of the merchant firm. This ownership structure gives the customers an incentive to purchase from the same firm again. If other customers purchase from the same firm and the stock price of the firm is a function of its total sales, *ceteris paribus*, existing customers can realize an increase in their wealth. Firms also benefit from equity-based e-loyalty programs because of the lowered cost of customer retention and a potential change in their stock prices through increased sales.

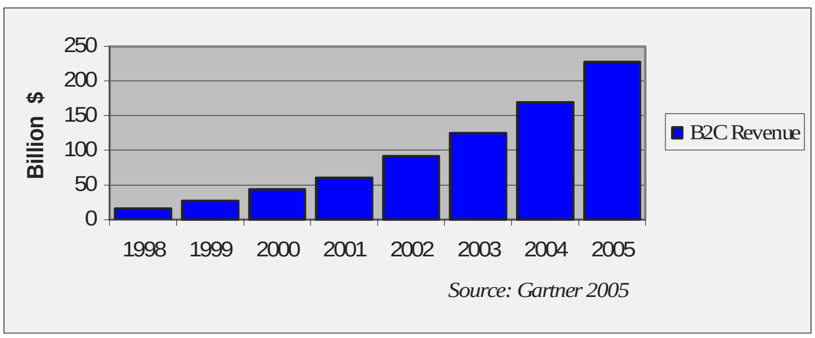
The incentive mechanism used in equity-based e-loyalty programs is very similar to the concept of executive compensation through company stocks, where executives become part owner of the company they are managing (Alchian & Demsetz, 1972; Holstrom, 1982; Jensen & Murphy, 1990). Although customer incentives in equity-based e-loyalty programs may not be as strong as that of company executives, firms can reinforce customer incentives by requiring that a certain amount of equity be collected by the customers before converting them to cash.

Another difference between cash-back rewards and equity-based e-loyalty programs stems from their technical requirements. Since equity-based e-loyalty programs involve stock transactions and firms conducting such programs may not have the necessary expertise in this area, an operational partnership with a financial intermediary is necessary. By using several forms of information technology (IT) such as customer databases, data warehouses and information exchange services similar to electronic data interchange (EDI), the financial intermediary can help firms handle stock transactions of customers and maintain their accounts online. Indeed, such partnerships have been a usual practice among the pioneer companies conducting equity-based e-loyalty programs. For example, *UPromise.com* has established strategic alliances with the Vanguard Group (*www.vanguard.com*) and the Sallie Mae Corporation (*www.salliemae.com*), while *Stockback.com* has partnered with the Share Builder Securities Corporation (*www.sharebuilder.com*). Table 1 summarizes main characteristics of the most popular e-loyalty programs currently conducted on the Internet.

Table 1. Comparison of different e-loyalty programs (in alphabetical order)

E-commerce Web Site	Service Offered	Program Details	Expected Effect
CashBackOutlet.com	Cash back	Cash back for purchases and referrals	Increased sales
ClickRewards.com	ClickMiles	Frequent flyer program	Increased sales
CommissionJunction.com	Marketing	Affiliate marketing	Increased sales
Ebates.com	Cash back	Up to 25% cash back	Increased sales
ELoyalty.com	Loyalty	Loyal customer	Loyalty
GreaterGood.com	Charity support	15% of sales amount may be donated to charity	Philanthropy
IGive.com	Charity support	26% of sales amount may be donated to charity	Philanthropy
LinkShare.com	LinkShare	Affiliate marketing	Increased sales
Performics.com	Marketing	Affiliate marketing	Increased sales
Spree.com	Cash back	Cash back for purchases and referrals	Increased sales
StockBack.com	Stock back	Equity-based e-loyalty program	Loyalty
UPromise.com	Mutual Fund	Equity-based e-loyalty program	Education

Figure 1. Worldwide B2C e-commerce revenue (© 2007, Yasin Ozcelik. Used with permission.)



CONCLUSION

Proliferation of the Internet and diffusion of IT throughout the world have created new business channels and enabled firms to expand their service palette. It is believed that business models utilizing innovative e-loyalty programs have a potential to advance business practice and increase profits of the Business-to-Consumer (B2C) e-commerce companies. An examination of the historical growth rates of the worldwide total B2C revenues in Figure 1 implies that e-loyalty programs indeed have a potential to increase revenues via repeat-sales in these markets.

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KEYWORDS

Business-to-Consumer (B2C) E-Commerce: A type of electronic commerce in which products and services are marketed and sold by a firm to individual consumers through a Web-based application. Consumers can check product prices and specifications on the firm's Website, and they can place their orders online without visiting a store or consulting to a sales representative. There are different types of business models in the B2C e-commerce, including portals, online retailers, content providers, transaction brokers, and service providers. Among the well-known B2C companies are *Amazon.com*, *Dell.com*, *Apple.com, Expedia.com,* and *Etrade.com.*

Data Warehouse: A large database that collects an organization's transactional and customer-related data in a single logical repository for analysis and managerial decision making purposes. The data can originate from many operational areas of the organization, such as Website transaction logs of customers, online shopping carts, point-of-sale terminals in stores, warehouse inventory, and field sales reports. Through the use of data mining tools, complex algorithms and filtering techniques on the data collected in a data warehouse, organizations can track their customers' behavior online, and identify their needs and common problems. Data warehouses can provide managers with a more complete and accurate profile of their customers, which can be used to tailor product and service offerings in line with customer expectations.

Electronic Data Interchange (EDI): A computer-to-computer communications standard for exchanging digital business documents among firms, such as invoices, purchase orders, price lists, and shipping bills. EDI standards were first developed in late 1970's and have been evolved since then. The main goal of EDI is to reduce errors, delays, and cost of document exchanges by digitizing and standardizing documents. EDI messages are organized with distinct fields for each of the important pieces of information in a commercial transaction such as date, product specifications, amount, addresses, and names. EDI has become an important industrial network technology standard by enabling faster communications among a small set of strategic partners and establishing long-term relationships. The technical infrastructure of EDI systems has significantly evolved from mainframes to personal computers and wireless devices. Moreover, the telecommunications environment is changing from private dedicated networks to the Internet.

Electronic Loyalty (E-Loyalty): Repeated satisfaction of a customer with purchases of products or services from a specific e-commerce Website. The notion of e-loyalty extends the traditional definition of brand loyalty concept to online consumer behavior. It is described as an evolution from the traditional marketer-controlled concept towards a consumer-controlled and technology-facilitated concept. Among the factors creating e-loyalty are quality customer support, on-time delivery, comprehensive product information, reasonable shipping and handling prices, and clear and trustworthy online privacy policies. There are several metrics used to measure the level of e-loyalty for a specific e-commerce site such as the frequency of single user visits, and percentage of customers who return to the site to make additional purchases in a specific period of time.

Online Surveillance Technologies: A generic name for a technology that can track and monitor online activities of visitors to a specific website through the use of special software. Surveillance technologies can be used either with or without the consent of visitors, and they range from Internet Protocol (IP) tracking utilities to the analysis of server logs and network monitoring. The question of whether the implementation of surveillance technologies by e-commerce companies to better serve visitors is a security or privacy issue is still under discussion.

Shopbot: Short for "shopping robot", an intelligent software agent that can automatically search a large number of online stores for a specific product. Shopbots enable consumers to make a comparison shopping by displaying on a single page the prices and features of a product offered by different vendors. Among the well-known e-commerce companies utilizing shopbots are *www.bizrate.com*, *www.mysimon.com*, and *www.pricegrabber.com*. As the cost of searching on the Internet increases, the value of shopbots is expected to increase in the near future.

Switching Cost: The broad term used for the cost of inconvenience imposed on a customer due to switching from a product, service, brand, or a firm to another. Since switching costs are more psychological and less financial, it is difficult to quantify them. There is a strong relationship between switching costs and customer loyalty. If the level of the switching cost of a customer for a specific brand is higher than a threshold, then the customer does not have an incentive to switch to another brand, and hence remains loyal.

Enhancement of Recorded Respiratory Sound Using Signal Processing Techniques

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INTRODUCTION

Pulmonary auscultation has been the key method to detect and evaluate respiratory dysfunctions for many years. However, auscultation with a stethoscope is a subjective process that depends on the individual's own hearing, experience, and ability to differentiate between different sounds (Sovijarvi et al, 2000). Therefore, the computerized method for recording and analysis of pulmonary auscultative signals, being an objective way, are recently playing a more and more important role in the evaluation of patients with pulmonary diseases.

Noise interference is one of the most influential factors when dealing with respiratory sound recordings. By definition of (Rossi et al, 2000), any sound not directly induced by breathing is regarded as background noise (BN). BN is divided into two types: environmental noise, which consists of continuous noise and transient noise, and nonrespiratory sounds and body sounds (muscle contraction sounds, skin friction, and heart sounds). The adaptive filtering is usually used to reduce the background noise. However, the problem of existing proposed filtering methods are either not able to minimize the interference or provides distortion which is especially undesirable for biomedical signals (Donoho, 1992).

Furthermore, segmentation of the respiratory sound into its inspiration and expiration phases is also necessary in quantifying adventitious sounds in the analysis stage. Spirometer has always been used together with sound recording devices to provide the forced expiratory volume (FEV) readings (Taplidou et al, 2007) (Cortés et al, 2005) for segmentation purpose. But it could be difficult to carry out a spirometric test for wheeze patients with high obstruction in tracheal (Cortés et al, 2005). Not much work has been done on respiratory sound segmentation using sound signal alone. Most developed approaches are in automatic speech segmentation, and they are based on the hidden Markov model.

In this article, we introduce a newly developed respiratory sound signal enhancement system. It consists of the implementation of the proposed signal preprocessing and enhancement scheme to produce clean respiratory sound waveforms without attenuating any useful signals. Heartbeat, as the major body sound, is first removed using notch filter. Next, by applying nonlinear energy operator (NEO), the system is able to detect and remove spikes which reflect the transient environmental noises. The wavelet denoising subscheme then suppresses the continuous environmental noise to minimum level without distortion. Last, we introduce a new segmentation algorithm to segment the signal into its inspiration and expiration phases for future analysis purposes without incorporating the FEV readings from spirometer. A graphical user interface (GUI) is provided by the system for clinicians to monitor the process of respiratory sounds recording, enhancement, and segmentation. By processing the raw recorded respiratory signals using the preprocessing system, the output signals carry only useful information and are ready for analysis.

MATERIAL AND METHODS

Test Dataset

Tracheal breath sounds signals from 10 healthy students of Nanyang Technological University are used as the dataset of the present study. The sample size of 10 consists of 6 females and 4 males, each producing two clips of 20-second recordings. All clips have been verified to be normal tracheal breath by Dr. Daniel Goh from National University Hospital of Singapore. At the same time, one standard preprocessed normal tracheal breath signal and two preprocessed wheeze signals from (Lehrer, 2002)(Tilkian et al, 2001)(Wilkins et al, 2004) are used together with the recorded data to test the automatic segmentation method.

Acquisition of Respiratory Sounds

The recording environment and equipments are chosen based on the standard given by (Rossi et al, 2000). Short-term recordings are done in sitting position in audio laboratory which provides a quiet environment. One electret condenser microphone (ECM-77, Sony, Inc., Tokyo, Japan) is inserted into a hemispherical rubber chamber 2cm in diameter, and placed at suprasternal notch of the test subjects to record the tracheal breath sounds. Recording software WAVEPAD (V3.05, NCH Swift Sound Software) is used and the signal clips are recorded and saved as monochannel *.wav file at sampling frequency of 44.1 kHz. Test subjects are asked to breathe normally, and 20-second recording is saved each time.

The Proposed Enhancement Method

The proposed enhancement scheme is to remove background noise (BN) while keeping the useful information unaffected. This has been realized by staging through three steps: The first step is to remove the heartbeat using notch filtering. The signal would then be passed through the nonlinear onergy operator to detect and remove spikes. The last step would be to remove very high frequency/small detail components in the signal, so as to preserve the underlying signal structures which might be corrupted by noise. A block diagram of the proposed enhancement technique is depicted in Figure 1. The scheme is realized in the following steps:

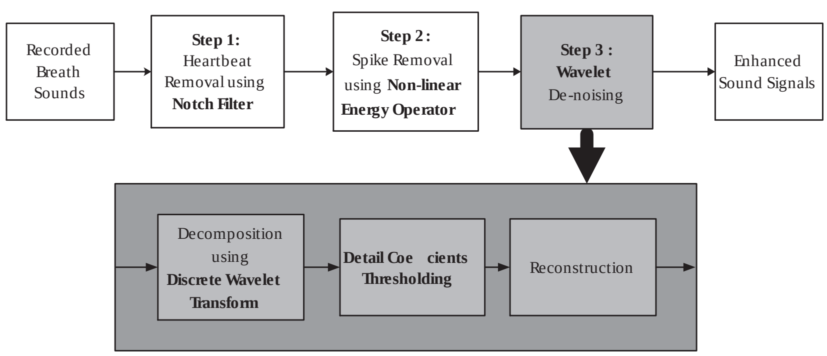
Step 1: Heartbeat Removal Using Notch Filter

The first stage of enhancement scheme involves removing the heartbeat from the respiratory sound signal. Heart sounds falls in the low frequency range of a few Hertz to over 200 Hz, but with predominant range below 100Hz. It has been suggested in (Sovijarvi et al, 2000) that a low-order highpass filter would be sufficient to remove heartbeat from the respiratory sounds. However, it also removes some of the important signals which may fall in the same frequency as the heartbeat. In order to avoid the loss of useful information, notch filter is applied here to solve the problem. The frequency response of a notch filter provides deep notches, which are useful to eliminate/attenuate some specific undesired frequency components of a signal (Haykin et al, 1988). The notches are made as deep as possible, so that ideally the undesired frequencies are totally eliminated. It is implemented using a second order (N=2) Butterworth filter. The stop band is defined in this case to be $f_{stop} = [f_1 \quad f_2]/F_s$ where $f_1 = 10\text{Hz}$ and $f_2 = 300\text{Hz}$ with sampling frequency $F_s = 44.1\text{kHz}$·

Step 2: Spike Removal Using Nonlinear Energy Operator

Spike refers to both a localized high frequency and an increase in instantaneous energy in the signal processing point of view. The quantitative descriptions of the amplitude and spectrum of spikes vary from signal to signal, subject to subject; it even varies from time to time for the same subject. For this reason, detection and pathological implications of spikes become difficult. As the width of the spikes increases, energy is concentrated more in the low-frequency band where the energy of the background signal is also located.

Figure 1. Block diagram of the proposed enhancement scheme



Also, detection becomes more difficult in the frequency domain. And therefore an energy-based spike detector known as the nonlinear energy operator, also known as the Teager operator, has been suggested to improve the spike detection (Kim et al, 2000). It estimates the square of the instantaneous product of amplitude and frequency of a sufficiently sampled signal. In this respect, the NEO is considered to be superior to other energy estimators that simply average the signal energy and are independent of frequency.

In the proposed scheme, input signal is resampled at a lower frequency of 16 kHz to reduce the computational load. The nonlinear energy operator is defined in (1) as

$$\psi[x(n)] = x^2(n) - x(n+1)x(n-1) \tag{1}$$

where $x(n)$ is the input audio signal with heart sound removed. It is then convolved, as indicated in (2), with a 6-point Barlett window, $w(n)$. It is chosen to keep the complexity of the algorithm as low as possible and at the same achieve sufficient reduction of interference without losing resolution.

$$\psi_s[x(n)] = \psi[x(n)] \otimes w(n) \tag{2}$$

Once filtering in (2) is done, the peaks can be identified by the output of the filter compared to a threshold. In this enhancement scheme, the threshold is taken as a scaled version of the mean of the filter output. This modification makes the detection algorithm robust. The threshold, T is chosen as given by

$$T = C\frac{1}{N}\sum_{n=1}^{N}\psi_s[x(n)] \tag{3}$$

where N is the number of samples and C is the scaling factor. It is selected experimentally as $C = 35$ to achieve the best result in spike detection within respiratory sound. The values at the spike locations are assigned to be 1 for the detected spikes. This is done iteratively for several loops (e.g., 3 loops) to ensure that adjacent spikes which may miss when the algorithm is run for the first time will be detected in the subsequent trials. After spike detection, an averaging method is applied for the spike removal. A global mean of the input signal $x(n)$ is used to replace the spike instead of imposing a silence (i.e., a zero-value), which can be considered as artifact for respiratory sound signals.

Step 3: Wavelet Denoising

One of the major difficulties faced in the analysis of tracheal sounds is the presence of environmental noise in the signal. Noise from instruments such as ventilator, air-conditioner, or ambient noise may contaminate the signal (Kandaswamy et al, 2004) and severely degrades the sound recognition system which we wish to develop. For noise removal, we have considered to use wavelet techniques since they are more suitable for transient analysis. (Here, we assume that noise is not a continuous or periodic signal, but a transient signal.) Wavelet denoising of the respiratory sound is performed to remove high frequency/small detail components. It preserves the underlying signal structures which may be obscured by noise while performing the denoising. Another feature of wavelet denoising is to improve the perceptual quality of sound in order to reduce listener's fatigue (Soon et al, 1997).

The underlying basic model for the noisy signal is described in (4).

$$s(n) = f(n) + \sigma\, e(n) \tag{4}$$

where $f(n)$ is the clean signal, σ is the noise level, and $e(n)$ is a Gaussian white noise $\boldsymbol{N}(0,1)$. Noise removal using wavelet transformation is based on thresholding techniques and derived mainly from the early work of Donoho and Johnstone (Donoho, 1995), in which both signal and noise coefficients are distinguished using a selected threshold.

The basic idea of wavelet denoising is to compare the wavelet coefficients to a given threshold and is set to zero if its magnitude is less than the threshold; otherwise it is kept and modified (depending on the threshold rule)(Chang et al, 2000). The denoised signal is finally obtained by the inverse discrete wavelet transform (IDWT). This wavelet thresholding procedure removes noise by thresholding only the detail wavelet coefficients, while keeping the low resolution coefficients unaltered.

DWT coefficients are thresholded here by heuristic SURE thresholding (Donoho et al, 1995) strategy which depends on the energy of the particular subband. Soft thresholding is chosen as in practice especially when noise energy is significant, it provides no abrupt artifacts in the denoised signal as it is not discontinuous as hard thresholding. A suitable wavelet type, for example, sym8 wavelet, is selected by considering its noise removal ability for our recorded sound clips. Last, a denoised signal is reconstructed by IDWT using the thresholded detail coefficients.

Automatic Segmentation of the Enhanced Signal

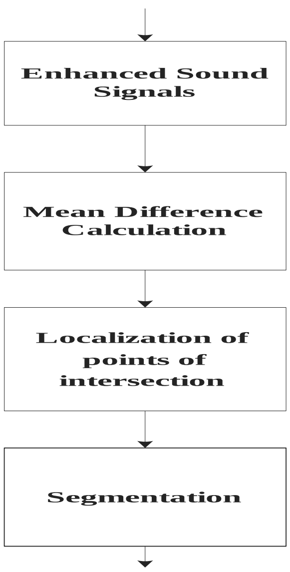
In the next stage of preprocessing method, the enhanced signal will be segmented into its inspiratory and expiratory phases. The steps for segmentation are illustrated in Figure 2. Our proposed segmentation method is based on initial idea of change point detection. Two adjacent windows of equal length of *M* are passed through the data sequence. The width of the windows should not be allowed to exceed the length of the smallest segment. Window of length *M*=64 samples is used in our case. At each time sample, the values of the mean difference is calculated by comparing the absolute mean of the second window to that of the first window; it is known as mean difference measurement. This mean difference sequence $d(n)$ is then passed through a 1-bit quantizer/comparator:

$$y(n) = \begin{cases} +1 & d(n) > Th \\ -1 & \text{elsewhere} \end{cases} \tag{5}$$

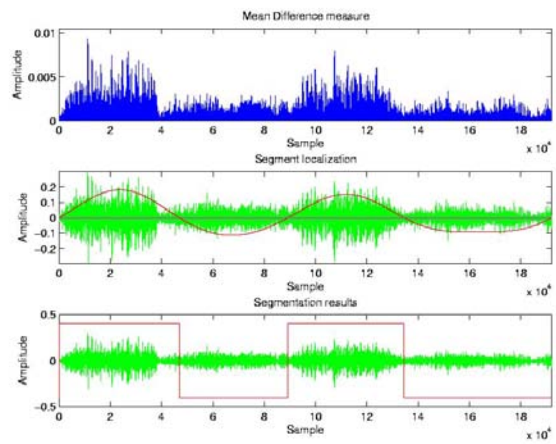
where $y(n)$ is the output of the 1-bit quantizer and Th is the threshold.

The maximum (max) and minimum (min) values of $d(n)$ is used to set a threshold. In this article, we found that the suitable threshold value to be (max + min)/3. Using the mean difference $d(n)$ calculated earlier, any value that lies above the threshold is considered as inspiration phase (set to be +1) and values that fall below the threshold are considered as expiration phase (set to be -1). In order to estimate the phase duration of each cycle, the output $y(n)$ is passed through an integrator, which is a low-pass filter designed in the frequency domain. Then the distances of the zero-crossing points between the zero-axis and the lowpass filtered output estimate the durations of the inspiration and expiration phases of each cycle.

Figure 2. (1) Block diagram of the automatic segmentation method; (2) segmentation of wheeze sample clip; (a) mean difference measure; (b) localization of intersection point; (c) segmentation results



(1)



(a)

(b)

(c)

(2)

ILLUSTRATIVE RESULTS

Experimental Results

The 20 recording clips are used for the testing of our enhancement scheme. The recorded data are trimmed to include three cycles of respiratory phases each. The waveforms of the enhanced recorded signal are shown, in a step by step manner in Figures 3 to 7. As the performance of the system for all 20 clips are consistent, and due to the page constraint, only one of the sound clips with normal tracheal breath is chosen for display.

Heartbeat Removal

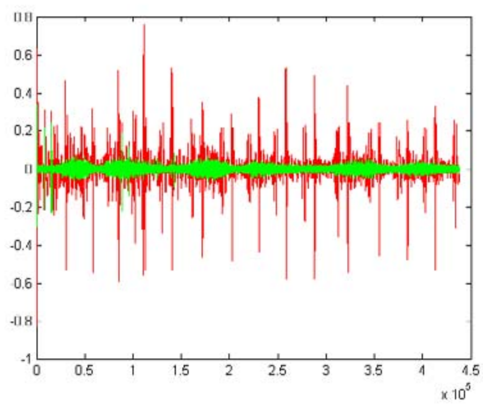
The dark grey signal (red in color plot) in Figure 3(a) refers to original signal, while the light grey signal (green in color plot) which is imposed on it denotes the enhanced signal as filtered by a second order high-pass filter with cut-off frequency of 200Hz. This shows that the signal is significantly smoothed and the inspiration and expiration cycles can be seen clearly. This heartbeat removal is very important as it allows certain features of the respiratory sound to be extracted as needed for segmentation. From the subjective hearing test, it is observed that the processed signal has totally removed the presence of heartbeat; however, the respiratory sound is slightly attenuated by the high-pass filter.

The result of the second order Butterworth notch filter with band-stop between 5Hz and 150Hz is shown in Figure 3(b). Although the waveforms of both enhanced signals are quite similar, but in terms of subjective listening test, an improvement of signal quality is observed with notch filtering. Heartbeat is normally completely removed from the signal. Although in few cases whereby the presence of heartbeat is especially strong, there will still be some residues of the heartbeat sound after high-pass filtering. Another observation is that the respiratory signal after notch filtering shows no attenuation unlike the high-pass filtering. Hence, the notch filter is chosen as it ensures the original respiratory signal remains unchanged after passing through the filter; it is of outmost important in the preprocessing of biomedical signals.

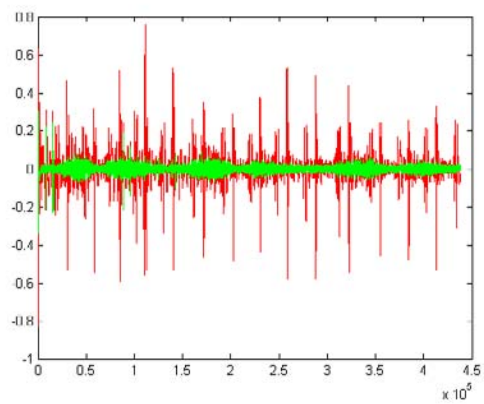
Spike Detection and Removal Using SNEO

The signal is processed and passed through the spike detection algorithm. The NEO and SNEO energy levels are calculated and the samples with an energy level higher than the soft threshold (with scaling factor of 20) are denoted as spikes. Figure 4 shows the detection results of spikes. After spike detection, the comparison has been made between two spike removal methods: the averaging method and the LPC method. For averaging method, the spike detected is replaced

Figure 3. Processed signals after (a) highpass filtering; (b) notch filtering superimposed on the original sample

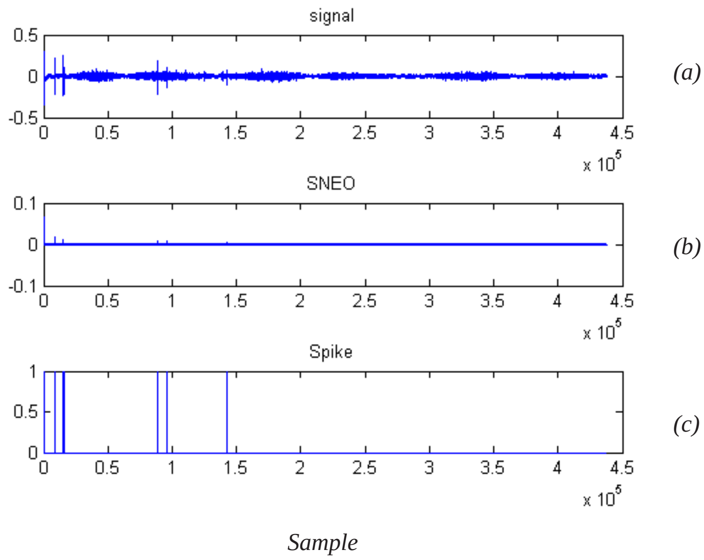


Sample (a)



Sample (b)

Figure 4. Processed signals after notch filtering; (b) smoothed nonlinear energy operator (SNEO); (c) spike detected using SNEO



by the signal mean as shown Figure 5. It is clearly seen that the majority of the spikes are removed/reduced by the averaging methods. If the input signal has too many outliers, the output signal sounds distorted in subjective hearing test, while for the LPC method, the spikes are removed using the LPC algorithm which estimates a value for the spike as depicted in Figure 6. The removal of spikes is just as good as the averaging method; however, the quality of the signal is decreased due to the resampling of the signal at 8000Hz. The averaging method is chosen due to its much faster computational speed. Furthermore, it does not alter the quality of the signal by resampling the signal to a much lower sampling rate.

Noise Removal Using Wavelet Denoising

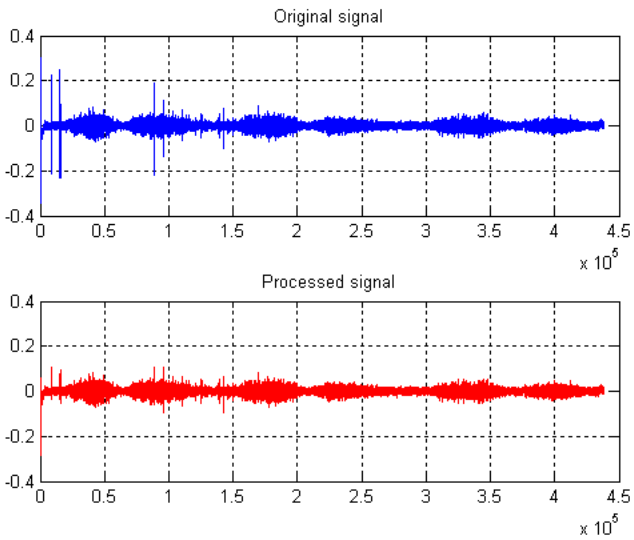
The signal undergoes the denoising algorithm as the last preprocessing stage. Figure 7 shows the expanded version of the first 2 seconds of the signal after processed by the algorithm. It could be seen that the output signal is smoother as the high frequency components are removed. Also, by doing subjective hearing test, the background noise is clearly attenuated but not totally removed.

Subjective Test Results

Subjective testing is done on the preprocessed signals. A group of 20 subjects took part in this testing. They consisted of 11 males and 9 females ranging from 19 years old to 27 years old. The test is conducted at the Media Resource Laboratory to ensure consistency in testing as the amount of surrounding noise may affect the judgment of the evaluators. The test samples consist of five different recordings chosen randomly for 20 different subjects. Each recording consists of three inhalation and exhalation cycles and the subject is asked to judge the overall degree of improvement for each of the five processed samples over the original ones. The rate of improvement is evaluated by a -9 to 9 scale whereby -9 represents a much worse sample and 9 represents a much better sample after processing. Table 1 shows the average results obtained from the 20 evaluators.

It is observed that there is only a small variation in the rating, 0.77, between the best and worst samples. This shows that the algorithms work well for various samples. The results obtained are encouraging. From the 20 subjects who took the test, only 2 felt that the

Figure 5. Processed signals (a) after notch filtering; (b) after spike removal using averaging method

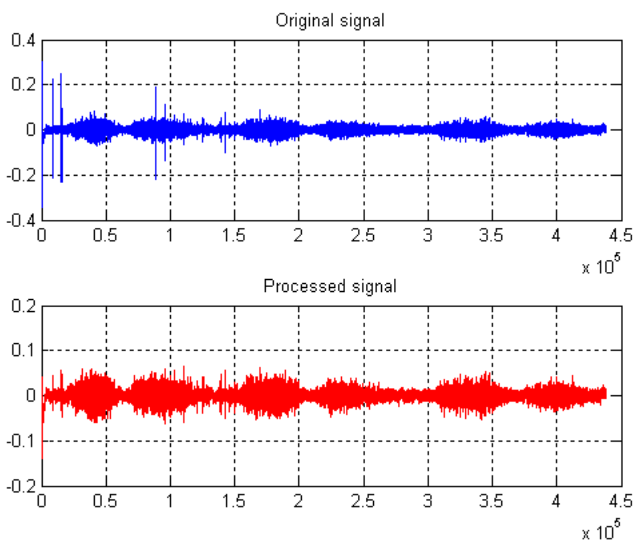


(a)

(b)

Sample

Figure 6. Processed signals (a) after notch filtering; (b) after spike removal using LPC method



(a)

(b)

Sample

Figure 7. Time expanded signal: (a) before (b) after wavelet denoising

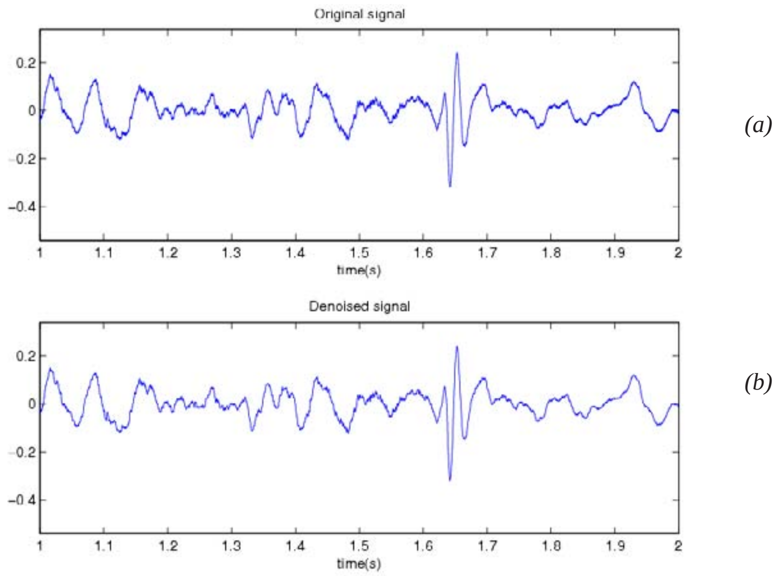


Table 1. Subjective test rating obtained from a sample pool of 20 people

Subjects	Mean Opinion Score
9 Females	4.2
11 Males	6.2
Total	5.08

processed signal sounded almost the same as the original signal. The overall average rating (i.e., mean opinion score) is about 5.08 which indicates the efficiency of the enhancement scheme. The general opinion is that the amount of background noise can be attenuated further as it is still noticeable even after processing. Also, for low intensity signals, the performance of the scheme is not as good as that for high intensity ones. This indicates that the input signals should have high SNR in order to be used for analysis.

Limitation

For the low SNR case, the denoising scheme has not performed well. This is due to the characteristic of biomedical signal. Unlike other types of audio signals (such as speech), fine details of the biomedical signals are required to be preserved for analysis. And usually, this desired information is covered by more prominent signals which are produced by other body parts. Therefore, the input respiratory signals are required to have good quality in the sense that high SNR is necessary. Thus, a good recording environment and equipment are crucial to the preprocessing process by means of providing high SNR input signals.

CONCLUSION

The proposed system performs quite effectively in enhancing and segmenting input respiratory signals. The low computational complexity makes the real-time process possible. GUI of the system has already been designed and the system has been tested in real-time case. Furthermore, it is significant to involve the segmentation scheme as segmenting the signal is a common practice in quantifying abnormal tracheal sounds such as wheeze. So far, besides our proposed scheme, there has been no other method proposed for segmentation of respiratory sounds without the FEV readings. This significantly simplifies the hardware implementation of the system and makes the system portable-possible.

E

This proposed respiratory sound enhancement scheme can be used as a part of sophisticated health care information system in the pulmonary rehabilitation clinics. It could work as an information storage and retrieval system in medical care. It would provide medical information based on the recorded observed data and helps the respiratory experts (doctors, therapists) in decision making for the patients with breathing disorders and chronic lung problems, such as asthma, bronchitis, and emphysema based on reliable preprocessed respiratory data. The system can also help in pulmonary education and home monitoring of chronic pulmonary disease such as asthma.

ACKNOWLEDGMENT

The authors would like to thank Dr. Daniel Y. T. Goh, National University Hospital (NUH), for his suggestions for the verification of the recorded tracheal sounds.

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KEY TERMS

Background Noise (BN): Any sound not directly induced by breathing is regarded as background noise.

Denoising: Denoising is any signal processing method which reconstruct a signal from a noisy one. Its goal is to remove noise and preserve useful information.

Heartbeat Removal: A signal processing technique to remove the heart sound as acquired during sound recording, resulting a continuous pure respiratory sound stream.

Respiratory Sound: All sounds related to respiration including breath sounds, adventitious sounds, cough sounds, snoring sounds, sneezing sounds, and sounds from the respiratory muscles.

Segmentation: Segmentation means audio segmentation which is partitioning an audio stream into its homogeneous units. It refers to partition respiratory sound stream into individual inspiratory and expiratory phases.

Spike Removal: A signal processing method used to remove noise of impulsive type. It involves the recognition and localization of spikes, which are short time broadband in nature.

Subjective Test: A subjective test session is a sequence of trials where different implementations of the proposed method are compared. Each trial provides several audio files. Each one is the result of the processing of a compared method on a reference-nondegraded file.

E

ERP Integration into Existing Courses: A Three-Step Approach

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INTRODUCTION

In recent years, there have been extensive discussions in the information system (IS) community on how to best respond to developments in the information and communications technology (ICT) industry. Some of these discussions have focused on the changing skills of IS graduates and have identified the need for graduates to have an integrated understanding of business processes and the ability to work effectively in teams to solve key business problems in the ICT industry.

To better respond to the ICT changes, many firms have implemented companywide information systems called enterprise resource planning (ERP) systems to help improve their productivity and customer service while lowering costs and inventory levels. The inherent appeal of ERP has not gone unnoticed in the business curriculum either. Several business schools (Babson College, Louisiana State University, University of Idaho, University of California at Chico, University of North Carolina, and Grand Valley State University, among others) have made systematic changes across their business curriculums to ensure that they graduate students with an integrated understanding of business processes and ERP systems. These schools have mirrored the approach followed by companies in various industries by abandoning the traditional vertical, functional organizational structure in favor of a more horizontal, cross-functional structure (Bailey, Chow, & Haddad, 1999; Gwin & Gwin, 2000; Johnson, Lorents, Morga, & Ozmun, 2004; Ryan & Luthy, 2000; Stover et al., 1997).

Apart from the ability of ERP systems to serve as a focal point for integration of information across functional areas, other benefits obtained from integrating ERP into business curriculum include exposing students to how business processes extend across an organization and its value chain, and helping students understand the concepts surrounding the adoption and implementation of enterprise-wide systems (Bradford, Vijayaraman, & Chandra, 2003). Other important benefits for students include: (1) exposure to real world software that illustrate real world business processes, (2) enriched cross-functional curriculum in which students obtain a broader perspective of the organization, (3) exposure to the caliber of technology with which students will work in their careers, (4) desirable and higher paying jobs because of stronger knowledge of company operations and substantially less training required, (5) ability to contribute earlier than most new people to the projects that they are assigned, (6) ability to translate requirements in meaningful analysis for applications, (7) bringing a higher level of confidence to work, and (8) better prepared for challenges and also less whining when the going gets rough (Peslak, 2005; Vluggen & Bollen, 2005).

Since most of the existing literature focuses on integrating ERP across the business curriculum, this article looks at how ERP can be incorporated within an existing course. Specifically, based on our experiences with teaching ERP in our respective courses, we discuss the different options and levels of integration that can be achieved in a particular course. We hope that our insights and experiences with ERP implementation would be of value to other faculty members who are contemplating incorporating ERP into their courses.

BACKGROUND LITERATURE

Recognizing the integrative and multidimensional nature of ERP systems and the value it adds to the business curriculum, researchers have started to extensively examine ERP implementations in business schools all across the world. For example, several studies have examined and illustrated the implementation of ERP across

Table 1. Summary of ERP literature pertaining to business curriculum

Author(s) (year)	Findings
Gibbon and Aisbett (1999)	Recommend that ERP systems be taught through understanding the history of business information requirements.
Hawking et al. (1999)	Provide a mechanism to integrate ERP teaching in the information systems (IS) curriculum model across 11 levels of knowledge relating to fundamentals of IS.
Ongkasuwan (1999)	Proposes a cost-effective approach for incorporating SAP R/3 into the management information systems (MIS) curriculum of MBA and BBA programs.
Quinton (1999)	Provides recommendations and guidelines concerning the inclusion of SAP R/3 into a business curriculum in the context of a strategic alliance with an ERP vendor.
Rivetti et al. (1999)	Consider the ERP educational strategy as a curriculum integration mechanism to re-adjust the educational delivery that focuses on standard functional areas towards a more integrated business process approach.
Watson and Schneider (1999)	Recommend the concept of a multi-layered approach to ERP concepts and education
Becerra-Fernandez et al. (2000)	Explores specific methodologies to teaching ERP in the undergraduate curriculum.
Wagner et al. (2000)	Discusses how business schools are using ERP software as an integrative teaching tool.
Stewart and Rosemann (2001)	Propose the use of case study and action research approaches in researching and teaching aspects of postgraduate ERP related programs.
Bradford et al. (2003)	Highlight the reasons for adopting or not adopting ERP for classroom use based on a business school survey.
Selen (2001)	Proposes the inclusion of basic business skills as part of ERP education.
Joseph and George (2002)	Suggest the use of learning community to instruct students in ERP systems.
Cannon et al. (2004)	Suggest an alternative integrative case approach for integrating ERP in the business curriculum.
Davis and Comeau (2004)	Provide a good example of how to design, deliver and measure the outcome of a course on enterprise integration at the undergraduate level.
Fedorowicz et al. (2004)	Describe 12 tips for successfully integrating ERP across the curriculum.
Grenci and Hull (2004)	Provide a framework for using traditional systems analysis and design concepts with ERP-specific concepts.
Johnson et al. (2004)	Recommend a customized ERP/SAP model for business curriculum integration.
Peslak (2005)	Recommends a 12 step, multiple course approach to teaching ERP.

a varying number of business classes and disciplines in the undergraduate and graduate curriculum (Becerra-Fernandez, Murphy, & Simon, 2000; Cannon, Klein, Koste, & Magal, 2004; Corbitt & Mensching, 2000; Hawking, Shackleton, & Ramp, 1999; Ongkasuwan, 1999; Peslak, 2005; Quinton, 1999; Stewart & Rosemann, 2001; Wagner, Najdawi, & Otto, 2000). Table 1 provides a summary of the ERP literature pertaining to the business curriculum.

Even though integrating ERP into curriculum provides extensive benefits to students, there are certain barriers that influence the success of these initiatives. According to several researchers (Fedorowicz, Gelinas, Usoff, & Hachey, 2005; Johnson et al., 2004; Michaelsen, 1999; Still & Petty, 2000), the challenges that business schools are facing in integrating ERP into the curriculum include: (1) very time consuming, (2) resource drain, (3) alteration of course content, (4) pedagogical challenges, (5) faculty resistance, (6) faculty reward structure (teaching load issue), (7) faculty members' lack of understanding of other disciplines, (8) difficulty in accommodating part-time students and transfer students, and (9) student resistance to limitations in schedule flexibility, among others.

Based on our experience with ERP, we recommend the following: First, identifying and motivating the faculty who would be instrumental in leading this initiative; second, forming an official faculty team/committee and giving them the responsibility to incorporating ERP in the curriculum, including the sequencing of courses; third, acquiring adequate funding to support all of the resources needed to implement a system of this magnitude, including funding for equipment, faculty training, new teaching facilities, and so forth; fourth, setting up a technical infrastructure and a corresponding support team to install, monitor, and administrate the ERP systems; fifth, identifying and getting support from local companies that have implemented ERP; and sixth, we spent our time on developing fictitious and/or real cases and other related material to customize our ERP efforts. All the above steps need to be addressed in the first year of implementation. Once our ERP was successfully launched, we focused our efforts on: (1) marketing our programs, (2) expanding our course and content offerings, (3) working closely with local companies and other partners, and (4) expanding our faculty pool.

INTEGRATING ERP INTO THE CURRICULUM

In this article, we propose the following three-step process to integrating ERP into an existing course: essential knowledge, integrative knowledge, and expert knowledge. Typically, these stages should be implemented in progression. However, we recommend that educators select the stage with which they are most comfortable with in terms of knowledge, time, and available resources. In the essential knowledge stage, we believe that all students need to be exposed to:

- An overview of business processes and ERP systems. A detailed PowerPoint presentation that discusses ERP systems, business processes, and ERP software such as SAP is essential. We would also encourage the faculty to discuss employment opportunities in this field and provide Web sites that students can refer to for more information. This practice usually seems to be an eye-opener and a great motivator for students. Typically, short essay questions or multiple choice questions on an exam can be used to assess the students' knowledge.
- A practical hands-on demonstration of ERP software. The purpose of this demonstration is to educate the students on the basic business processes and the integrative capabilities of the ERP software. By assigning an exercise or several exercises in which the students can see how a transaction/process affects other functional areas is extremely beneficial. When planning exercises, make sure that each exercise addresses a specific issue and limit the number of exercises to about five. For example, in our operations management core course, we usually focus on the product manufacturing and planning module. Typically, this type of knowledge can be imparted in 3 to 6 hours of class time. To test and ensure learning, students are required to do at least one graded exercise on their own and several graded team exercises.
- Ideal course/courses for this type of overview would be an Introduction to Business and/or Introduction to Operations Management and/or Introduction to MIS. At our school, the essential knowledge of ERP is imparted in the introductory operations management and information system

courses. Most of our students get excited when we cover the ERP component. Several of our students then take other courses that focus more on ERP.

In addition to the above, if faculty want to incorporate more ERP coverage, we recommend the *integrative knowledge* phase. In this phase, not only are the students required to do more integrative and detailed exercises, but are also required to do at least one case analysis. Several of our faculty members teach SAP configuration and integration using a fictitious skateboard case company which was developed in-house. Through this case dealing with very few products, students are guided through the configuration and creation of organizational structures, master data, and transaction rules for the company. By the end of the case analysis, students gain a high level understanding of functionality and integration of the following core SAP modules: financial accounting, internal controlling, procurement and inventory management, product manufacturing and planning, and sales and distribution. Students also see the reality of how different types of flows (materials, data, information, and financials) take place within an integrated system. In other words, they not only see how transactions/processes go through the various stages but also how they impact the various disciplines/areas.

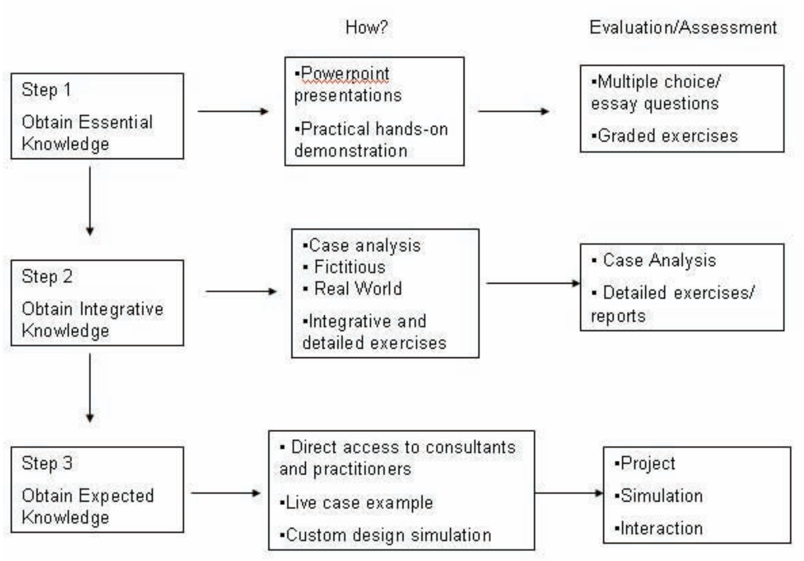
In addition to this fictitious case, some of our faculty members require students to discuss and analyze a real-world ERP implementation case of a local company. This case was also written by our faculty for teaching purposes. This case highlights the critical factors that facilitated and/or inhibited the success of the ERP implementation at the case study company. When teaching this case, the chief executive officer or chief information officer of the case study company is usually invited to the class to be a part of the discussion. Typically, faculty members who teach these two cases spend 9 to 15 hours on ERP topics. As far as student learning and assessment is concerned, about 30-40% of the course grade is assigned to the fictitious and/or real-world case analysis. At our school, we have several courses in our operations management (e.g., quality management, strategic operations management, and manufacturing planning and control) and information emphasis (e.g., introduction to enterprise information systems, business process reengineering, and project management) that cover the above material. Other courses that cover the extended model of the fictitious case include a human resources management and a strategic management course. Overall, we receive very positive comments regarding the ERP coverage.

The third stage of ERP integration is referred to as expert knowledge. At this stage, one goes beyond the knowledge of the faculty and allows students to have a direct access to consultants and practitioners who are knowledgeable and working on a day-to-day basis with ERP. Not too many schools, including ours, have reached this level. A classic example of this stage would be the new graduate Harnessing Enterprise Technology and Innovation course introduced at the University of North Carolina at Chapel Hill. In this course, students: (1) explore a live case example of strategic planning for an ERP system with Rick McWhorter, Boston Scientific's vice president of operations, (2) participate in an ERP audit with IBM, (3) learn firsthand about the role of data, business intelligence, and integrated analytics from Jared Schrieber, senior supply-chain and global industry consultant with NCR Teradata, and (4) participate in a custom-designed simulation that demonstrates the impact of business process changes due to the ERP implementation. This simulation was developed by Steve Desirey, business planning manager for SAP implementation at DuPont (Roth, 2005). To do this right, we recommend a full course be devoted to the real world project and audit. Otherwise, we recommend this methodology be adopted in the upper-level courses and/or capstone information systems and operations management course. Students should be assessed on the quality of their projects, simulation results, and the interaction they have with the business executives.

CONCLUSION AND FUTURE DIRECTIONS

We strongly believe that in today's competitive global environment, every business student should graduate with an understanding of basic business processes in an integrated environment. By integrating ERP systems into business curriculum, this objective can be achieved. Several universities (The University of Idaho, Babson College, University of Idaho, University of California at Chico, Grand Valley State University, among others) have made systematic changes across their entire business core with an intention to achieve a higher level of integration. Other integration efforts have focused on a

Figure 1.



subset or "block" of courses within the core and have often centered on experiential learning. The approach of block level integration requires varying degrees of coordinated faculty effort, specifically, joint teaching of formerly separate classes with team teaching and a single grade.

In this study, we describe and illustrate a three-step process to integrating ERP within a course. The three steps are: essential knowledge, integrative knowledge, and expert knowledge. We recommend that these steps be implemented in progression and that educators select the stage with which they are most comfortable with in terms of knowledge, time, and available resources. Figure 1 provides a pictorial representation of the three step process.

In the future, we see many faculty members moving towards expert knowledge. Faculty teaching these courses have realized that students can be better served if practitioners are also involved. Also, in the future, we will be seeing more virtual classrooms. This would allow for two-way delivery of ERP concepts, among faculty, practitioners, and students, on a real-time basis.

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KEY TERMS

Business Process: A collection of related activities that produce something of value to the organization, its stakeholders, or its customers. Software that reproduces these business processes, therefore, can be both internal (ERP system) as well as external (e-commerce software).

Core Curriculum: A set of courses that are deemed necessary and usually made mandatory for all students of a school or school system.

Enterprise Resources Planning (ERP): A software application that integrates (or attempts to integrate) all data and processes of an organization into a single unified system. A key ingredient of most ERP systems is the use of a single, centralized database to store data for the various system modules.

SAP: The largest business application and ERP solution software provider in the world in terms of revenue.

SAP R/3: The world's most-used standard business software for client/server computing. It is based on various hardware and software architectures, running on most types of UNIX, on Windows NT and OS/400.

Virtual Classroom: An electronic classroom where instruction involves the synchronous or asynchronous use of electronic learning tools such as video-conferencing, online classrooms, whiteboards, chat rooms, document cameras, and so forth.

E-Tutor

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INTRODUCTION

Many scholars believe that e-tutor support in a virtual learning environment is critical for the success of a student's learning experience. Several reasons support this belief: "practical reasons such as reduction of drop-out rates, theoretical reasons such as mitigating student isolation, and moral reasons such as the obligation to help students succeed" (Denis, Watland, Pirotte, & Verday, 2004).

Notwithstanding, the e-tutor profile is still uncertain and calls for deeper investigation and analysis.

This paper aims to present a framework of competencies for specific e-tutor roles, through a literature review and personal experience.

LITERATURE REVIEW

Probably used for the first time in 1997 in online educational programs for American schools, the term e-tutor is now normally used in various countries and contexts. Other expressions currently used in literature to refer to this figure are online tutor, online moderator/e-moderator, distance education tutor, e-teacher, cyber-teacher, online facilitator, and so forth.

What do these expressions stand for? Various authors use these terms with different meanings. While it is emphasized that in distance education the e-tutor intervenes as a "mediator" between the institutions, the course's subject matter, and the students, the term is, however, also used in a wider sense as proposed by Cornelius and Higgison (2000): "We use the term 'tutor' in its broadest sense to include, amongst others, academics, faculty, instructors, corporate trainers, animators, facilitators, moderators, subject specialists and learning support staff. The term online tutor includes any person undertaking a role to support and enable students to learn online effectively".

According to Jaquinot (2002) e-tutoring is a service given to the students in distance learning in order to make "the signs of presence appear". Laurent, Gagne-Iattoni, and Lessard (1992) describe online tutoring as a wide advising activity, the objective of which is that of breaking isolation. Simpson (2002) and Lentell (2003) stress that the figure of tutor in online learning environments is necessary to make the student overcome isolation.

Among the e-tutor functions Barker (2002) cites pastoral care, while Rayn, Scott, Freeman, and Patel (2000) and Lentell (2003) advocate the facilitator role in the Rogerian sense. In these definitions attention is given to the individualization of the learning program, the support provided in order to overcome learning difficulties, and the importance of this figure in satisfying the relational need that the e-learner may feel.

Other analyses propose to consider e-tutor roles in the framework of the pedagogical model of the course where the e-tutor operates. Berge and Collins (1996) distinguish between three roles: instructor, facilitator or moderator. Briefly, in the role of instructor the e-tutor is more oriented towards support of contents and must be a subject matter expert. As a facilitator the e-tutor is mainly engaged in guiding discussions, providing methodological support and motivating online learners. As a moderator, the e-tutor takes care of managing interactions, discussion groups and online collaborative groups.

Moving from Mason and Kaye (1992), Calvani and Rotta (2000) suggest the analysis of e-tutor roles, considering the methodological model involved in the online course. E-tutors are prevalently experts/trainers in distance courses based on the instructor-centered approach, as in many courses the objective of which is the transmission of learning contents ("content + support" model). They are guides able to value the potentialities of learners in online courses oriented towards the development of practical skills (learner-centered approach, "wrap around" model). E-tutors are "mediators" in a broad sense when applied to a learning group-centered model grounded on collaboration and peer learning as in many courses based on the so-called "integrated" model (learning-team-centered approach). Compared to instructor or facilitator, the e-tutor moderator/animator plays a proactive role even if in the context of more advanced courses where students have more control on learning process, his/her role is no longer central, being inclined to operate "back stage" and leaving greater space for interaction between the students (Palloff & Pratt, 1999, 2003). It is evident that an e-tutor moderator/animator carries out functions of mediation in the management of relational and communication processes. As Berge (1995) specifies, the e-tutor moderator is a central subject in the teaching/learning process and possesses characteristics similar to those of the animator of virtual communities. The same value as Berge's is given by Salmon (2000), with the term moderator used to mean a tutor—typically distinguished from expert/guide of contents—who stimulates and guides the interaction between a group of students engaged in sharing knowledge and comparing points of views in the virtual learning environment. In both cases, the scenario is one in which participants in the learning community should develop curiosity, accept feedbacks on their own performance, diagnose their learning needs, formulate objectives adequate to their capabilities and aspirations, identify human and experiential resources, and work out a personal or collective project. Such situations would not be sustainable without the support of a specific figure—that is, the e-tutor—able to guide learners and to use appropriate strategies in order to manage such complex educational processes.

Just the same, Trentin (2004) defines the e-tutor as "a professional figure which is not a simple assistant/counsellor, but rather a manager of collaborative learning processes, based on the intensive use of the net" (p. 32). This figure acts mainly in virtual spaces based on computer-mediated communication, and favours network learning processes. The e-tutor therefore is a "tutor of a network of individuals" cooperating to reach a common learning objective and as such is "the propulsion motor of all the network learning processes" (p.34).

E-TUTOR ROLES AND FUNCTIONS

What ideas have emerged from the above analysis? Is it possible to identify a single and coherent e-tutor profile?

First of all, we agree with Daniel et al. (2004) who stress that there are confused ideas regarding the definition of the e-tutor roles. This confusion partly depends on the different expressions used to define the same role/function. For example, the expression e-tutor or e-teacher is often used to indicate a figure that plays the same roles of a facilitator. In other cases, the same expression is used to indicate figures that carry out different roles or functions especially in situations where the expression "online tutor" is used to indicate both an instructor and a facilitator.

Secondly, we agree with the idea that the role and functions of e-tutor depend on the pedagogical model which characterises the course where his/her action is performed. If we generalized, and did not consider the pedagogical model, we would risk making a mistake.

In this chapter, we focus on the functions and competencies of an e-tutor who operates in a learner and/or team-centered pedagogical model, and therefore on functions and competencies of an e-tutor facilitator/moderator.

How can we represent these functions? One of the most renowned analysis goes back to Berge (1995), who proposed a model widely taken up again by subsequent studies (Bocconi & Pozzi, 1999; Rowntree, 1995; Salmon, 2000; Shepherd, 1999; Trentin, 1999). According to this perspective, the four main areas crucial for effective e-tutoring are:

- Technical**,** assuring the correct functioning of the technical system and helping the participants resolve technical troubles
- Pedagogical, supplying intellectual stimulus, defining the subjects of discussion or activity, offering support for the comprehension of contents
- Managerial, intervening in the procedures and management, and in work planning (e.g. schedules, deadlines, etc.)
- Social, promoting the creation of a cohesive atmosphere of mutual trust within the discussion group, or collaborating in observing and monitoring interpersonal dynamics while trying to solve possible conflicts and misunderstandings

In developing the analysis of Berge, Daniel et al. (2004) propose a more analytical distinction between central and peripheral roles of e-tutors, highlighting the following as central roles:

- Content facilitator (the e-tutor intervenes sometimes as an expert on the subject, or as interpreter and guide through the concepts of study, etc.);
- Metacognitive facilitator (supports reflection on learning activities and outcomes, study skills development, etc.); process
- Facilitator (supports learning strategies, time management, etc.);
- Advisor/counsellor (provides pastoral support, doorway to institutional/local support systems, etc.);
- Assessor (gives feedback on task achievement and performance, assignment development, is sometimes also examiner, and so forth;
- Technologist (stands as a guide, first-post support with technologies and tools for learning, etc.);
- And finally, resource provider (identifies and locates, develops and produces resources to provide "just in case" or 'just in time' learning support, etc.)" (Daniel et al., 2004).

Two of the peripheral roles are those of manager/administrator and e-designer. As manager, the e-tutor supports the management of the course, keeping records and checking enrolments. As e-designer, he intervenes sometime to help design the course or the "lesson" itself, the tasks to be done, etc.).

In the analysis of Daniel et al. (2004), attention is hardly given to the function of community manager, which appears to us as very central since the e-learning scenarios are always more oriented towards the integration of active learning and professional online communities for continuing education (Rotta & Ranieri, 2005).

In synthesis, starting off from the Berge's model integrated with suggestions emerging from recent literature (Denis et. al., 2004; Rivoltella, 2006; Rotta & Ranieri, 2005), we propose the following table of e-tutor facilitator/moderator tasks (Table 1).

E-TUTOR COMPETENCIES

From the Table 1, it appears to be evident that the competencies an e-tutor should possess are situated on various multiple levels.

Many scholars agree that a good e-tutor should possess a range of competencies, that are technical, pedagogical and methodological, managerial and communicative-relational (Kemshal-Bell, 2001).

By **technical competencies** we refer to the ability to use (at intermediate or advanced levels) the asynchronous and synchronous communication tools (i.e., e-mail, forums, chat lines, audio or videoconferences, page editing HTML, etc.) and the tools available in the virtual learning environment adopted in the course. In addition, the ability to supply technical help (help desk) and the knowledge of Netiquette principles. This means that the e-tutor must not only teach Netiquette to the students, but also make the students observe these principles in order to guarantee a good communication ecology.

Going on to competencies, even if an e-tutor may not necessarily be a subject matter expert, he/she must be able to indicate meaningful resources to the students (Denis et al., 2004). This entails the possession of basic domain knowledge which must not be less than the knowledge learners have (Lentell, 2003).

Pedagogical/methodological competencies include the ability to design and manage meaningful learning activities, noted as "e-tivities" (Salmon, 2002), moderate group interactions, encourage participation, motivate students, stimulate them intellectually, sustain them in managing schedules and organizing learning activities, monitor the learning process, and evaluate the student's performance. As to monitoring and evaluating processes, it must be observed that analyzing a process carried out in a virtual learning environment is other than banal. The virtual learning environment stores a lot of data on the users activities. This data can be an important source of information on the quality of the works going on. However, precisely because of the abundance of available data one needs to know how to make use of support tools at times incorporated in the same virtual learning environment. On the basic level, such tools allow, for example, to verify who, among the students, have (or have not) read a certain message as well as those who have (or have not) downloaded a specific document and so on. There are also more complex tools able to restore data in aggregate form on the group's interaction. Knowing how to make use of them becomes essential to effective monitoring of the learning process.

The sphere of **communication skills** and **relational competencies** entails a deep knowledge of computer-

Table 1. E-tutor roles

AREAS OF INTERVENTION	TASKS AND ACTIONS
Technical	Supply instruction and advice on the use of communication tools (e-mail, Web forum, chat, audio-videoconferencing, groupware, etc.).
	Provide information on Netiquette principles and rules.
	Help the students who are having technical difficulties.
Pedagogical/Methodological	Contribute and provide methodological support in course design (from content organization up to the design of online activities).
	Offer support for comprehension of contents.
	Nurture the intellectual atmosphere through various types of stimulus (questions, pointing out new sources, etc.).
	Sustain the motivations of students through meaningful learning activities.
	Offer metacognitive support, stimulate the students to reflect on their own learning path, give suggestions on how to organize their study time and on the most suitable strategies to reach their learning objectives.
	Monitor and evaluate the progress of the students.
Managerial	Set up and organize the virtual learning environment.
	Present the educational contract clearly.
	Mediate between institutions and the student and try to interpret the student's demands.
	Plan and manage activities (deadlines, rules, etc.) to sustain the rhythm and nurture interest.
	Offer support in the gathering and organizing of documentation
Social, communicative and relational	Promote a sense of cohesion and mutual trust.
	Observe and monitor the communicative and social-relational dynamics, intervening in cases of conflict, misunderstanding, etc.
	Manifest the capability of "listening" and immediately intervening when need arises.
	Promote profitable exchange among the students and facilitate interaction.
	Encourage the students on the emotive level.

mediated communication and of its implications on the emotional and socio-relational experiences of the individual and of the group. Moreover, it implies the capacity to listen and dialogue, observe and continually monitor the relational dynamics, promote constructive interaction among the students, moderate discussions, produce appropriate messages, and also identify the context and decode the messages by reading between the lines, facilitate personal expression, and reassure or encourage the students by helping them manage their emotions. This area of competencies is one of the most complex, but at the same time holds a crucial importance up to the point of becoming the core of effective e-tutoring (Ardizzone & Rivoltella, 2003; De Luca & Friendenthal, 2006; Fata, 2004; Rizzi & Tassalini, 2006; Rotta & Ranieri, 2005).

Finally, as far as the areas of **managerial competencies** are concerned, the tasks include the ability to organize work spaces, manage time, plan activities (deadlines, rules, roles) or define objectives, thus

Table 2. E-tutor competencies

E-TUTOR'S COMPETENCIES	DESCRIPTION
Technical	• Use synchronous and asynchronous communication tools • Possess knowledge of Netiquette principles
Pedagogical/Methodological	• Design and manage meaningful learning activities • Moderate group interactions • Orient, support and motivate students • Stimulate student's cognitive and metacognitive processes • Monitor the learning process • Evaluate the student's performance, giving formative feedback
Managerial	• Time management • Plan and monitor activities • Mediate between different needs from the students, the staff and the institutional organization
Social, communicative and relational	• Be "present" online (listen and give feedback) • Promote constructive interaction among the students and dialogue • Encourage the student by helping him/her manage his/her emotions

mediating between emerging needs along the way on behalf of students, staff or the educational institutions themselves.

The e-tutor competencies framework can be briefly synthesized (see Table 2).

CONCLUSION

As we have seen, in online education the e-tutor can hold various roles which are a set of whole and complex tasks and functions not strictly pedagogical. It would be rightful to ask if each of these identified roles is to be played by different people or by an only figure who must/may assume more roles. Is the figure of the e-tutor, in other terms, a specific professional profile to be introduced as new within the educational system, able to play the various roles we indicated? Or should it be more correct to speak of e-tutoring when referring to a whole set of functions that can be distributed to the whole educational system and be carried out by a team composed partly of people already operating in the educational institution, and whose competencies are only to be updated, and partly carried out by people coming from outside?

This is quite a complex problem which research is investigating (Rivoltella, 2006). The solution is not simple since questions of various nature come into play (organizational, administrative, labour related). However, in online education the e-tutor, as compared to the traditional tutoring, is gaining a more central role in instruction (support for educational content provision, management of interactions, evaluation).

It is therefore urgent to recognize the specific role of this figure within the institutional context, which is both necessary and auspicious in guaranteeing quality in any educational activity carried out on the network.

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KEY TERMS

Asynchronous Communication Tools: Asynchronous communication tools allow communication at different times and different places. These tools enable people to connect together at each person's own convenience. They include different tools such as e-mail, listservs (automated e-mail lists), bulleting boards, newsgroups, blogs, and wikis.

Computer Mediated Communication (CMC): It refers to human communication via computers and includes different forms of synchronous (i. e., instant messages, chat rooms) and asynchronous (i. e., e-mails, Web forums, blog) interaction between two or more individuals. Studies in CMC focus on the social and emotional effects of different computer communication systems.

E-Learning: A Neologism created at the start of the '2000s to indicate a set of methodologies aimed at using the ICTs in order to provide learners with learning resources and interactions free from temporal and spatial constraints. Three main solutions can be distinguished: content + support, wrap around, and integrated model. These three structures are respectively based on content, teacher's support for activities between peers and the Internet, and the collaborative learning group.

E-Moderator: The term is used to refer to a tutor who stimulates and guides the interactions between a group of students engaged in sharing knowledge and comparing points of views in a virtual learning environment.

E-Tivity: The term has been introduced by Salmon (2002), who defines e-tivities as a framework "for online active and interactive learning". The e-tivities main features are: "A small piece of information, stimulus or challenge (the "spark"); online activity which includes individual participants posting a contribution; an interactive or participative element- such as responding to the postings of others; summary, feedback or critique from an e-moderator (the "plenary")" (Salmon, 2002).

E-Tutor: The term is used in literature together with other expressions like online tutor, e-moderator, facilitator, and so forth. to indicate an educational figure of crucial importance in the online teaching and learning context. E-tutoring covers a wide range of roles, which Berge (1995) has categorized into four main areas: pedagogical, social, managerial, and technical.

Facilitation: This concept goes back to humanist psychology and particularly to Rogers. Starting off from the supposition that all human beings by reason of their psychological structure are apt to develop their potential, learning is intended as a process of facilitation oriented towards an offering of support to the abilities of self-management and self-development that individuals naturally possess.

Synchronous Communication Tools: Synchronous communication tools enable real-time communication in a "same time-different place" mode, and allow people to connect instantly and at the same time. They include different tools such as video and audio conferencing, and real-time text-based tools (chat rooms, Internet Relay Chat (IRC) and ICQ (I Seek You) instant messaging services).

E

Evaluating Usability to Improve Efficiency in E-Learning Programs

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INTRODUCTION

The history of usability began almost 20 years ago when computers were about to be used outside the designer and programmer environment. Until the 1980s software was mostly produced and used by designers so usability was taken for granted.

In 1983, the first computers providing a graphic interface and a mouse were produced by Apple for distribution on a large scale. The gradual introduction of computers to offices and houses began creating usability problems. The development of computers was guided mainly by the technology available at that time. Gradually, the impact of training costs, errors in the interaction between user and computer, and the evolution of studies regarding the "human factor", carried out by psychologists and ergonomics experts, led to a reflection on the importance of the target users.

In order to facilitate usability, the first guidelines regarding the human factor were introduced (the first guidelines regarding the graphic interfaces were written by Apple in 1978). The first user models were developed on the basis of research in the field of cognitive psychology which emphasized the human limits in elaborating detailed information and establishing the minimum requirements that a software needs to possess. In the first usability laboratories, usability, and ergonomics experts worked to develop guidelines and user models as well as to evaluate product usability. In that period cognitive ergonomics developed as a result of the application of cognitive psychology theory to both interface planning and the dialogue between user and computer. However, these developments were not enough to establish usability. In addition, likely usability defects detected during the final phase of evaluation could be rarely corrected because of cost and time problems. The first attempts to change this situation were done thanks to the integration of the *waterfall model* to the traditional usability activities. The analysis of requirements phase was intermingled with new methods aimed at improving the identification of the user's needs in terms of functionality and usability. Rapid-prototyping was introduced in the project phase and usability tests were often administered.

In the second half of the 1980s, in Scandinavia, the so-called *participatory design* encouraged the user's participation in the design process, not simply as an individual but also as a member of a certain culture and organization. On the other hand, the *user-centered model* or *human-centered design* that began to be adopted at the end of the 1980's, was characterized by three aspects (Norman & Draper, 1986):

- **Direct involvement of the target user:** In all the development phases from the analysis of the requirements to the final evaluation, the target user is as responsible for the product as the designer is
- **Interactivity of the process:** This process is articulated in cycles characterized by prototyping, evaluation and prototype changes, and achievement of the final product
- **Multidisciplinary team that designs a product:** Different people (designers, usability experts, software developers, graphic designers, technical writers, etc.) are all concerned with the outcome of a product

SOME DEFINITIONS OF USABILITY

ISO/IEC 9126 standard (*Information technology—Software product evaluation—Quality characteristics and guidelines for their use*) defines usability as "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions". On the other hand, ISO 9241-11 standard (*Ergonomic requirements for office work with visual display terminals—Guidance on usability*) defines it as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use."

Researchers have struggled to clarify the concept of usability. According to Shneiderman (1992), usability includes factors such as *efficiency of use, learnability, memorability and satisfaction*. Moreover, Nielsen (1993), one of the leading experts in this field, defines usability as a measure of the quality of a person's experience in interacting with a product or a system. As a consequence in his opinion, a product is usable when it can be learned quickly and effectively, and enables a user to accurately complete a task, is memorable, allows only few and noncatastrophic errors and is satisfying to use.

In short, a product is usable when:

- It fits the user's needs and expectations
- It is easy to understand, learn, use and is attractive
- It allows the user to work correctly, quickly and with satisfaction

Besides synthesizing various definitions of usability, these elements highlight the steps to follow during the product development cycle in order to ensure the usability of a product. In order to achieve this goal, it is necessary to know the users' characteristics, the activities that they perform and their environment. As for the ease with which users can understand and employ the product, today several usability principles and guidelines are available. They are mainly based on the cognitive and behavioural aspects of human-computer interactions. However, these aspects are not sufficient. To ensure usability, it is fundamental to interact regularly with future users. In this way it is possible to verify, evaluate and, if necessary, measure the project choices in terms of user satisfaction.

EVALUATING USABILITY

There are several methods to evaluate the usability of software and each one has specific characteristics that make it suitable to particular products during the initial, *in itinere* and final phases depending on the specific goals of the evaluation.

Usability tests need to be administered when the interface is in the planning stage. Evaluating once is not enough, however. Thus, it is advisable to repeat and integrate tests during all the process. Nielsen (1993) says that it is better to deliver a usability test with five people from time to time rather than only once with 20 users.

As stated before, usability is meaningful only when there is interaction with a user. Thus, in order to evaluate usability it is necessary to involve a user who is interested in interaction. As a consequence, to improve interactivity, studies of usability involve two major categories of analysis. The first is speculative and more economical: various experts analyze the software or an interface prototype on the basis of certain propositions in order to identify problems, ultimately providing a series of observations and suggestions for improvement. The second is more expensive but more precise: it is based on the direct observation of a typical user who tries to use the software during development. On the basis of the different tasks performed by the user and of the difficulties he/she meets, some suggestions may be made in order to facilitate planning.

The first category utilizes the following analytic methods for evaluating usability:

- Task analysis
- Cognitive walkthrough
- Heuristic evaluation

While these methods are all different, each of them utilizes expert evaluation. It is important to emphasize that this analysis is carried out on a subjective basis according to the analyst's preference or to general experience. Analysis is then carried out according to certain principles that are set on an empirical basis.

Task analysis concerns the examination of task components, estimating the steps necessary to develop a specific procedure. In the case of *cognitive walkthrough*, the cognitive features of users should be taken into account, checking the existence of any problems on the interface/prototype. *Heuristic evaluation* evaluates the interface on the basis of heuristic lists. They signify principles that have a high prediction value because they are the synthesis of the most common usability problems which are divided into categories.

These analytic methods are particularly useful in the initial project phases, when usability problems are so numerous that it would not be meaningful to "waste" subjects (who represent a considerable cost) to point out any mistake that could be easily identified by one or more experts.

In contrast, the second category of analysis is composed of several empirical methods designed to evaluate usability:

- Analysis of execution time
- Satisfaction questionnaires
- Direct observation with error annotation
- Thinking aloud

Some of these methods require laboratories equipped with video cams or time testing devices. Expert professionals are required to manage the methods because it is necessary to plan experimental designs in order to control problems concerning individual variability and the lack of naturalness of the situation. This necessitates experience in coordinating the setting, in delivering tests and in analysing the results which need to be properly classified and possibly subjected to statistical analysis.

The duration of these procedures is variable and can have an impact on costs. The methods that employ the observation and analysis of the subjects' behaviour can be more useful in the advanced phases of the planning process. This happens after the redesigning stage that follows the initial evaluation and is directed by analytical methods or when a more precise study on the specific functions of an interface is needed. Moreover, the empirical techniques, when repeated different times during various phases, make quantifying improvements possible.

As already stated, it is important to set goals and to use the most appropriate techniques to evaluate usability from time to time. In fact results of an analysis that utilized the proper technique may be deemed invalid if the process was initiated with erroneous assumptions. It is advisable to administrate several tests during the planning stage so that it is possible to correct errors and to retest products.

USABILITY IN E-LEARNING PROGRAMS

In an e-learning program, adopting usability criteria does not automatically cause the program to become "usable". This is evident when observing the program dropout rate which is often independent of the implementation of the usability criteria.

In the past, the criteria adopted to evaluate an e-learning program referred only to software applications. Today, there are many excellent e-learning platforms designed to develop and manage training environments. However, the utilization of a functional and viable e-learning platform does not guarantee its proper implementation. Thus, the contributions to the failure of several e-learning programs can be attributed to platform contents and to the way in which teaching materials are organized and presented to users (Conti, Guelfi, Genuini, Masoni, & Shehaj, 2005).

The companies which provide Web products should first analyze and evaluate their potential users. However, in a training setting, other elements should also be considered, such as teaching methods as well as the quality of the teaching and learning. As a result, the *user-centered model* becomes the *learner-centered design* because the students represent the target users of an e-learning product.

According to *learner-centered design*, it is necessary to consider the characteristics of potential students and the reasons why he/she has applied for an online course. Moreover, it is important to consider the following aspects:

- **Material learning time:** This variable is based on the observations and feedback from the students because during an e-learning course they modify their knowledge and motivations. For instance, someone who enrols in an online university course needs clearer and simpler study material and more time at the student's disposal rather than a student who attends the second or third year level of the same course. Designing simple initial lessons means motivating the freshmen to study and to attend the course.
- **Learning styles:** A student studies and learns better if the teaching method is closer to his/her learning style. The instructor should provide a variety of study material designed to satisfy the students' needs and reduce the material learning time.

- **Technologies:** They allow the implementation of complex software applications such as moving images, audio and video files, simulations, and so forth. When designing them it is necessary to consider the students' Internet access bandwidth that needs to be broad enough to allow the students to use the material. The designer should allow for all of these aspects in order to produce usable study material. To gather this information, it is possible to construct tests for implementation both before and during e-learning courses. In this way, it is possible to know the type of student involved and the student's expectations. Moreover, the personal experience of instructors and e-tutors should also be considered.

EVALUATING USABILITY IN E-LEARNING PROGRAMS

In addition to the rules and the guidelines for the evaluation of the usability of a software application, its efficiency can be determined by the number of users that access and use it every day. This is particularly true of e-learning programs where there are no formal measures in place to define their usability. This complexity is a result of the definition of the usability within e-learning settings. It is intended as *educational efficiency* that is quite different from the traditional concept of usability of software applications (Conti et al., 2005).

Determining the guidelines on usability in e-learning programs is not simple. The situations in an e-learning environment are varied because they are adopted from many fields of study, each with different teaching and learning methods. As a result, instructors, designers and students must cooperate in order to implement usable e-learning environments. Some practical development strategies may include: taking into consideration *user-experience*, integrating knowledge and research produced by people outside of the team and implementing competitive projects.

To evaluate usability in e-learning programs, some methods based on the *learner-centered design* can be adopted: the user-based method and the usability inspection method (UIM). The former is characterized by the *user-testing* technique which evaluates the application by collecting data from a sample of users who are actually using the system. However, the user-based methods are generally hard to implement because it is difficult to select the sample, to gather financial aid to train the users and to simulate the actual scenario.

On the other hand, UIM is a class of techniques involving trained evaluators, rather than real users, for examining a user interface. This method has been successfully adopted in the last few years although it has two main shortfalls:

- Most experts only evaluate the characteristics of graphical interfaces, without examining the structure of the application, the organization of information and its contents or the navigation process;
- Results depend exclusively on the expert's knowledge, experience and principles.

Both user-based methods and UIMs can be explored through two techniques: *heuristic-driven evaluation* and *task-driven evaluation.* The former evaluates the quality of an application by checklists and usability principles. Thus, in *user-testing*, heuristics are used to ask users to comment in a structured way on their experience by filling out questionnaires or participating in interviews. In UIMs experts use heuristics to explore material by checking compliance with the usability principles. *Task-driven (or scenario-based) evaluation* evaluates usability by trying to complete actions on the material provided. In this case, tasks should describe goals and sequences of actions that users might implement in user-testing while experts might implement in UIM.

These methods require criteria that take educational efficiency into account. In fact this is a fundamental characteristic in usable e-learning programs.

CONCLUSION

Everything considered, in order to contribute to reduce the dropout rate in e-learning courses, usability can fill a key role in building a good user experience as long as some requirements are taken into account:

- Meeting the needs of different users, analyzing time and learning styles as well as defining the goals for accessing the learning environment (goals related to communication, participation, belonging, simulation, reading, recording, knowledge structure, knowledge refreshment, and so on).

- Planning a learning environment that is sensitive to the current situation and independent of restrictions caused by limited access to certain technologies. As a matter of fact, there are several learning situations that might benefit from a variety of access channels. However, because of the variety of options available, it is essential that numerous methods of analysis are employed in addition to evaluating the assessment instruments. In order to build an enjoyable access experience, it is advisable to avoid duplication of facilities and functionalities on all access channels. Only a careful analysis of user behaviour will provide information about the actual advantages of each channel.
- Planning an interactive learning environment that offers the possibility of providing simulations and training. It is well known that if a student is emotionally involved in elaborating information, the student is more inclined to collaborate within the community.

To conclude, within e-learning settings the target user is represented by the student, whose needs and expectations should direct the product development process in order to allow the student to learn quickly and successfully.

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KEYWORDS

Effectiveness: Degree of achievement of a goal. Its measurement makes a connection between the fixed goals and the precision of the achieved goals. The simplest effectiveness index addresses the achievement of a goal: a product is effective when it allows the accomplishment of a task. If the goal is not achieved, effectiveness can be measured in terms of the number of operations necessary to accomplish the task. Another way to measure effectiveness involves the quality of the achieved results.

Efficiency: Relationship between the effectiveness level and the use of resources. It can be measured either by the number of errors made by the user before completing a task or by the time used to reach the goal. Efficiency can also be defined as the rate of effort used to successfully complete a task.

Ergonomics: Discipline that deals with the plan and the design of facilities and environments for human use. In the computer science field, it concerns the planning of keyboards, mice, screens, and of the workstation (chairs, tables, lamps, etc.).

Human-Computer Interaction: Discipline that deals with planning, evaluating and implementing interactive systems by human beings. Moreover, it deals with the study of the most important phenomena related to it.

Intuitivity: Degree of the effort rate required by a user in using a product for the first time. The less time and effort used, the more intuitive the product. This factor is very important in those products which involve occasional target users. It loses importance in those products which imply long learning sessions. An intuitive design makes comprehension of an object easy and improves information storage and recovery from memory.

Learnability: Degree of effort employed to achieve a level of competence in completing a task. A system is considered easy to learn if competencies required to use it are acquired after only a few repetitions of the task. The term "learnability" is widely used in the usability field sometimes as a synonym of "usability". It is fundamental to make the distinction between the usability of a product as it is being used for the first time and usability when referring to more or less expert users.

Satisfaction: Utility of an entire system as perceived by users and the comfort level felt by them in using a product. It is a subjective aspect of usability. It is difficult to measure and can be impacted by both effectiveness and efficiency level. In many cases it can be considered the most important measurement of usability. Satisfaction can easily be measured by asking questions of target users through a questionnaire or an interview or by making notes of the comments made by target users while they are using the system. A qualitative analysis of user satisfaction is also a good indicator. However, it can be most useful if their attitude towards a product can be quantified.

User Experience: Experience gained by a target user while interacting with an interface that provides access to a website or another technological product. The user triggers a series of cognitive processes that let the user understand the investigated reality. It is obvious that more the user has a positive experience, the more the user will wish to experience it again. The main factors that determine the quality of the user experience are: waiting time, orientation while surfing and surfing comprehension.

User-Centered Design: Process that implies the involvement of the target user during the planning and developing cycle. It is composed of several activities and it is based on the interaction of various instruments for analyzing, observing, planning, and assessing.

Factors Determining Teachers' Beliefs and Perceptions of ICT in Education

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INTRODUCTION

We live in the information age, at a time that *information and communications technologies (ICT)* permeate all aspects of our social activities (administration, business, industry, research, entertainment, culture, etc.) and radically influence our lives. ICT has been widely welcomed as having the potential to enhance learning by offering a variety of learning environments for the students and the adults as well. Educational systems around the world are under increasing pressure to use ICT in order to teach students the knowledge and skills needed for their future directions in the 21st century's *knowledge society*.

During the last decade, in most developed countries, a large number of educational initiatives have been directed towards ICT integration in the schools. In general, the approaches tried have been focused on

- The development of technology infrastructure in the schools
- The infusion of appropriate educational software in the schools
- The preparation of the teachers in order to adopt ICT as a tool efficient to enhance instruction and learning.

Even though educational policy directives have articulated clear and unambiguous statements about encouraging the use of ICT in the schools, the application of ICT in educational settings is rather peripheral acting, in most cases, as an "add on" effect to regular classroom work. Despite that home access to ICT has been growing rapidly, both for students and teachers, and ICT resources in the schools (computer labs, educational software disposal, connection with the Internet, etc.) have improved substantially over the last years, teachers do not appear to make effective use of ICT in their instruction (Becta, 2004a; Cuban, 2001; Russel, Bebell, O'Dwyer, & O'Connor, 2003; Waite, 2004). The outcomes of the initiatives concerning ICT in education are more evident in pupils' achievement in ICT capability than in applying their skills and knowledge to other subjects across the curriculum (OFSTED, 2004). On the other hand, it seems that individual attitudes and skill levels still remain an obstacle for the teachers to adopt ICT and make effective use of ICT in their instruction (Becta 2004a, Dexter, Anderson, & Becker, 1999; Lang, 2000).

Designing and implementing successful ICT preparation programmes for the teachers is considered to be the key factor to fundamental, wide-ranging educational reforms (Davis, 2003; Pearson, 2003; Unesco, 2002; Vosniadou & Kollias 2001; Watson, 2001). During the last years, initiatives directed to searching for efficient ways to prepare teachers to integrate ICT in their everyday instructional strategies have been of major priority in several countries across the world (Becta, 2004b; Dexter & Riedel, 2003; Hennesy, Ruthven, & Brindley, 2005; Knezek & Christensen, 2002; Lang, 2000; Niemi, 2003). Various programs have been implemented aiming at enhancing teachers' skills toward the pedagogical application of ICT as a tool to support instruction and learning (EC, 2002; 2004; ICTL, 2004; OFSTED, 2002; PT3, 1999; TTICTE, 2005).

There are three main questions requiring to be answered:

- Why ICT failed to induce a major impact in the schools compared to other disciplines in our modern society (administration, business, labor, research, etc.)?
- What factors support or prevent teachers from using ICT in their instruction?
- What type of educational directives and orientations could be encouraging for the schools and the teachers to integrate ICT in everyday practice?

In this article the factors involved in the uptake of ICT by the teachers and the schools are examined. The focus of our argumentation is that teachers constitute a critical factor in the attempt to integrate technology in the classroom but they are not appropriately prepared for that undertaking. An extensive review of the literature associated with teachers' views and perceptions of ICT in education is presented. Finally, we conclude debating on the demand of a new curriculum and a new pedagogical framework, both based on and enhanced by the new environments and tolls ICT offer in education.

WHAT ICT BRINGS IN EDUCATION

It is widely accepted that ICT would lead to significant educational and pedagogical outcomes in the schools, beneficial for both students and teachers (EC, 2004; ICTL, 2004; OFSTED, 2002). A great amount of research has shown that proper use of ICT in education can increase students' motivation and deepen understanding, promote active, collaborative and lifelong learning, offer shared working resources and better access to information, and help students to think and communicate creatively (Jonassen, 2000; Webb, 2005).

Nowadays, ICT is perceived to be inherent to the educational reform efforts necessary for the 21st century society, since it has changed the key aspects of the nature of knowledge and the way we access it. Moreover, ICT appears to change the very nature of teaching and learning, since the teaching profession is evolving from an emphasis on teacher-centred instruction to *student-centred* learning environments (Webb & Cox, 2004).

There are three main aspects inherent to the role of ICT and its impact in the schools:

The vocational aspect: ICT has lead to changes in the way people access and manipulate information, solve problems and organize their work. The required skills and competencies are therefore changing for both students and teachers. Gaining in importance are the following skills and capabilities:

- Critical and analytical thinking
- Decision making
- Handling dynamic situations
- Team working
- Effective communication
- ICT competencies.

The pedagogical aspect: ICT integration in the school practice is not restricted to a simple improvement of the traditional instruction but rather it is associated to fundamental changes in the learning process. In other words, ICT is widely perceived as a catalyst for school change, since it could bring major benefits to the learners and the teachers, such as:

- New educational materials
- Shared learning resources and environments
- Promoting *active and collaborative learning*
- Shift towards *autonomous* and *lifelong learning*.

The societal aspect: Societal pressures have been present since the launch of ICT into schools. Parents, television advertisements, industry, and commerce aspects, the Internet have all provided pressure for pushing ICT into education. Possession of a computer and an Internet connection line at home is a recent form of *social culture*. Several researchers have found that home computers were mainly used for games playing and the Internet as a leisure activity. This is usually not of positive benefit to school learning. For example, it can pose a problem if teachers feel threatened by pupils' superior knowledge of ICT (Jimoyiannis & Komis 2004) or if school hardware and software is far less up-to-date than that being used at homes.

In the field surrounding the design, application and integration of ICT in education, many myths and misconceptions have been developed and promoted across countries, educational institutions, policy makers, and educational planners. Attempting to analyze the critical issues related to ICT in education and the low impact in schooling produced till now, we present an outline of the myths and realities regarding the current influence of ICT into the schools. Following we analyze the key factors determining teachers' views and perceptions of ICT in education.

Myth 1: Putting computers into the schools will directly improve learning; more computers will result in greater improvements in education.

Reality 1: Till now, education has been affected by ICT only marginally.

Myth 2: Once teachers learn the basics of using computers and the Internet, they are ready to effectively use ICT in their instruction.

Reality 2: Teachers are not convinced of the potential of ICT to improve learning. Moreover, they are poorly prepared to effectively integrate ICT in their instruction.

Myth 3: There are agreed-upon goals and "best practices" that define how ICT should be used in the classroom.

Reality 3: Radical pedagogical reforms are required to take full advantage of the potentialities that ICT brings in education (e.g., shift from teaching to learning, active and collaborative learning practices, new roles for the teacher, new classroom organizations, flexible curriculum, etc.).

FACTORS AFFECTING TEACHERS' ADOPTION OF ICT IN EDUCATION

It is widely recognized that teachers' educational beliefs are strong indicators of their planning, instructional decisions and classroom practices (Bandura, 1986; Pajares, 1992). Van Driel et al. (2001) argue that reform efforts in the past have often been unsuccessful because of their top-down approach, which failed to take teachers' existing knowledge, beliefs, and perceptions into account. Teachers' attitudes and beliefs towards ICT in education have a significant influence on ICT adoption and their implementation behaviors in the classroom. Therefore, a thorough analysis of their conceptions towards ICT in education can provide insights on the prerequisites for teachers' successful preparation, in order to effectively apply ICT in their classroom.

Teachers, in general, agree that computers constitute a valuable tool and are positive about students' development in ICT knowledge and skills (Jimoyiannis & Komis, 2006). In most cases, they perceive ICT as a new area (subject-matter) in the schools rather than a new way of teaching and interaction between learners and knowledge (Loveless, 2003;Williams et al., 2000). It appears that, even though they recognize the importance of introducing ICT in education, teachers tend to be less positive about their extensive use in the classroom and far less convinced about their potential to improve instruction (Russel et al., 2003; Zhao & Cziko, 2001).

Teachers' attitudes toward ICT constitute a multifaced variable. Many instruments have been used to measure teachers' attitudes toward computers in education revealing four correlated dimensions (i.e., Evans-Jennings & Okwuegbuzie, 2001; Levine & Donitsa-Schmidt, 1998; Ropp, 1999; Rosen & Weil, 1995):

- *Anxiety*, *fear* or *cautiousness* of using computers and ICT tools
- *Self-efficacy* and *confidence* in the ability to use ICT
- *Liking to use computers* and ICT tools
- Perceptions about the *value and usefulness* of using ICT in education.

It seems that the teachers, in general, have a consistent *network of beliefs* and perceptions concerning the many aspects of ICT in education (Jimoyiannis & Komis, 2006). Goodwyn, Clarke, and Adams (1997) divided the English teachers participated in their survey into three groups according to their beliefs and rationales about ICT in the curriculum: (a) the optimists, (b) the fearful teachers and (c) the unresolved teachers. Similarly, in a survey administered in Greek schools, three cohesive groups of teachers have been identified according to their views and beliefs towards ICT in education: (a) the positive teachers, (b) the negative teachers, and (c) the neutral (undecided) teachers, which vacillate between positive and negative beliefs (Jimoyiannis & Komis, 2007).

The findings of the research, examining the factors relating to the uptake of ICT by schools, suggest that ICT integration in the school practice needs time and systematic efforts. The adoption of ICT by teachers and schools should not be considered as a linear and spontaneous outcome of the decisions taken by policy authorities and the funds invested by the government. Despite the great funding by national and EU authorities, it seems that the lack of

a. A *realistic pedagogical framework* of using ICT across the curriculum
b. An *effective system* for supporting-guiding teachers' professional development

does not work in a supportive way, as far as the integration of ICT in everyday school practice concerns.

Helping teaches to develop positive attitudes towards ICT in education is a complex task, determined by many interrelated factors affecting the network of beliefs, ideas, educational priorities and decisions they held. In this article we propose an integrated framework of factors, influencing teachers' perceptions of ICT in the schools, which is determined by four interrelated axes, namely *personal factors*, *technical barriers*, *school factors*, and *pedagogical factors* (Figure 1). The multidimensional nature of this framework is influenced by the many factors, *internal* or *external* to the teachers, which are analytically discussed in the next section of the chapter.

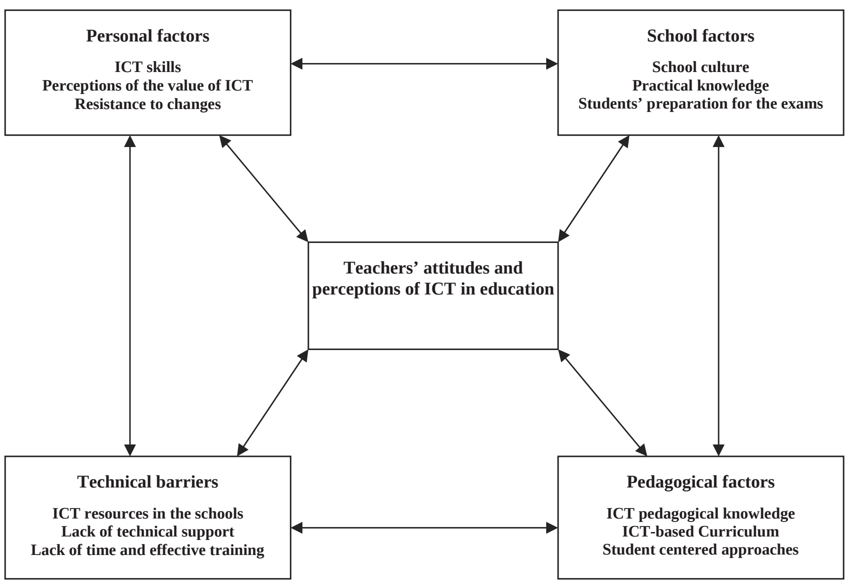
Personal Factors

Personal factors refer to the teachers' atomic characteristics, perceptions, or choices which determine their ICT profile and influence their beliefs towards ICT in education. A number of studies have investigated teachers' attitudes toward computers in education and revealed correlations to various variables such as *gender, age, subject specialty, ICT competence* and *teaching experience* (Christensen, 1997; Evans-Jennings & Okwuegbuzie, 2001; Jimoyiannis & Komis, 2006a; Levine & Donitsa-Schmidt, 1998; Ropp, 1999; Rosen & Weil, 1995; Yaghi & Abu-Saba, 1998; Yildirim 2000).

Gender differences: Research has shown that there are gender differences in teachers' beliefs about ICT and their engagement with ICT. Earlier studies reported that female teachers had a greater degree of computer anxiety (Brandley & Russel, 1997; Rosen & Weil, 1995) and were less confident computer users than males (Lee, 1997). A recent report (EC, 2003) noted that gender is an issue which determines the use of ICT by teachers, and the gap between males and females is even wider as far as the use of the Internet is concerned. Shapka and Ferrari (2003) claim that gender differences about computers seem to be diminishing. Similarly, it has been found that, in general, the males are positive about ICT in education while the females are neutral or negative (Jimoyiannis & Komis, 2006a). The findings of the survey indicate that gender is still a critical factor inducing positive beliefs about ICT in education despite that its importance is falling relative to previous studies in Greece (Emvalotis & Jimoyiannis, 1999; Jimoyiannis & Komis, 2004).

Age differences: A number of surveys suggested that the age of the teachers is a factor creating barriers to the use of ICT. A European Commission report (EC, 2003) found that the percentages of teachers using computers and the Internet fall as their age increases, while the importance of this factor is falling. Presumably, the younger teachers have been more exposed to technology than their predecessors. This could result in higher confidence levels and more positive views of ICT in education but it does not guarantee, by itself,

Figure 1. Factors influencing the adoption of ICT by the teachers



higher levels of ICT use in the classroom (Jimoyiannis & Komis, 2007).

ICT competence: Teachers' competence and confidence with ICT is a principal determinant of effective classroom use by the students. It seems that providing opportunities to the teachers to acquire ICT skills is critical in order to strengthen their beliefs about the value of ICT in teaching and learning (Becta, 2004a; Kumar & Kumar, 2003). Research also indicates that many teachers have positive attitudes toward technology but they do not consider themselves qualified to effectively integrate ICT into their instruction (Ropp, 1999). On the other hand, most findings suggest that teachers with ICT knowledge have a more positive attitude toward the potential of ICT in education (Cox, Preston, & Cox, 1999; Luan, Fung, Nawawi, & Hong, 2005; Jimoyiannis & Komis, 2006b). Lack of appropriate training and experience is considered one of the main reasons why teachers have negative attitudes toward computers and do not use technology in their teaching (Becta, 2004; Yildirim, 2000). The impact of effective teacher training on ICT could be measured in terms of changes in attitudes on the part of the teachers (Kumar & Kumar, 2003; Galanouli, Murphy, & Garder, 2004) and of their students as well (Christensen, 1998).

Teaching experience: The effect of teaching experience on teachers' attitudes toward ICT has not been extensively studied. Significant differences have been recorded in Greek teachers' beliefs and ICT skills according to their teaching experience (Jimoyiannis & Komis, 2006b). The teachers in the middle of their carrier (having 10-20 years of teaching experience) are positive to adopt ICT in their instruction while highly experienced teachers (having teaching experience greater than 20 years) are negative in general. Low experienced teachers (teaching experience less than 10 years), though they have higher level of ICT skills, are skeptical of the role of ICT in education. Similar results have also been found in a study concerning French teachers (Baron & Bruillard, 1997). Presumably, ICT adds extra efforts to the young teachers in their attempt to organize the core elements of their subject content, their instruction and the practices followed in the classroom.

Teaching subject: Although a fair amount of literature on teachers' perceptions of ICT in education is available, there is little evidence of the barriers which exist in specific subject areas (Becta, 2004a). Our findings indicate a close relationship between subject matter and teachers' attitudes about ICT in education (Jimoyiannis & Komis, 2006b, 2007). Generally, the business, technology and science teachers are positive while mathematics, Greek language, history, and social studies teachers are negative about ICT in education. Overall, our results confirm previous findings in the USA that the functionality of computers in the class has been quite different for the teachers of different subjects (Becker, 2001). It has been found in Becker's study that business education and elementary teachers reported that computer use occurred frequently during their classes, while mathematics and arts teachers did not use computers that often.

Grade level: Previous research findings indicate that teachers' grade level is a factor of importance. It appears that teachers teaching at the secondary level had higher self-efficacy than elementary teachers and were less likely to predict that they would give up or avoid a challenging ICT-based task (Rosen & Weil, 1995; Shapka & Ferrari, 2003). Primary school teachers tend to have higher levels of computer-phobia and were more likely to avoid ICT than high school teachers. In contrast, secondary teachers were more likely to use computers in the classroom, but were also more likely to exhibit gender-stereotypical attitudes (Whitley, 1997). Contradicting to the results discussed earlier, it has been found that Greek primary teachers were particularly positive about ICT in education (Jimoyiannis & Komis 2006a, 2007), especially in comparison with some of the secondary core specialties, for example, mathematics, Greek language, history, and social studies teachers.

Perceptions of the potential of ICT: Cox et al. (1999) have analyzed the role of *perceived usefulness* and perceived ease of using ICT in teachers' views about ICT in education. Recent studies (Hu, Clark, & Ma, 2003; Ma, Andersoon, & Streith, 2005) have found that teachers' perceived usefulness of ICT is a significant factor in determining intention to use ICT in their instruction. Teachers seem to ignore the *pedagogical characteristics* and the potential of ICT to engage students with learning in ways that otherwise were not possible. Moreover, they need more convincing reasons about the usefulness and the effectiveness of ICT in learning and instruction (Jimoyiannis & Komis, 2007). It is striking that 92% of the teachers participated in this survey considered ICT as a necessity in our modern society, exhibiting a consumer-like approach about its contribution in education.

Teachers' resistance to change: Fullan (2001) stated that the most fundamental problem in education reform is that people do not have a clear and coherent sense of the reasons for educational change, what it is and how to proceed. Previous research (Munby, Cunningham, & Lock, 2000; van Driel et al., 2001) has shown that teachers, in general, resist to fundamental changes in their everyday classroom choices or teaching activities (the model of knowledge transfer to the students minds, the conventional problem solving approaches, the accurate coverage of the content according to the curriculum or the textbooks, etc.). Veen (1993) describes this situation as the *persistence of beliefs*, for example, teachers hold views which persist and induce obstacles during the infusion of educational innovations. This justifies why the educational uptake of ICT by the schools is a slow process, with teachers needing time and support to gain experience and redirect their instructional practices by taking advantage of ICT as an efficient tool for learning (Mumtaz, 2001).

Technical Barriers

Into this category are classified technical and other external factors, related to the school and social environment, which inhibit teachers to get involved in ICT integration efforts. Following are presented the most important technical barriers teachers faced with.

Lack of resources: Lack of sufficient numbers of computers and appropriate software can seriously limit what teachers can do in the classroom (Pelgrum, 2001). The quality of the hardware available constitutes also a problem for the teachers. Mumtaz (2001) has pointed out that evidence of good practice in the use of ICT is invariably found in those schools that have high quality ICT resources. Cuban (2001), on the other hand, claimed that resources available in the schools are, in most cases, underused. In some cases, poor organization will also cause barriers to the teachers interested to use ICT in their instruction. In Greek secondary schools, for example, computer labs are predominantly used by the computer science teachers providing thus limited opportunities for the other subjects. Similarly, data logging systems, available in science laboratories, constitute a characteristic paradigm of underused equipment (Siorenta, 2005). Possession of a personal computer at home does not guarantee, by itself, enhanced willingness from the part of the teachers to use ICT in their instruction. A survey concerning Greek teachers has shown that only a small percentage (11.1%) used routinely ICT to support their conventional instruction, despite that 6 out of 10 teachers reported ownership of personal computer at home (Jimoyiannis & Komis, 2006a). On the other hand, only 1.7% of the teachers in the sample used ICT tools so often, mainly, as short episodes incorporated into the existing curricula and teaching practices.

Lack of appropriate software: In general, there is a lack of appropriate educational software in the schools. Although various educational software titles may be available for both teachers and students, most of those titles are not appropriate or cannot actually help in enhancing learning. Apart from poorly designed software, which disengages students from the intended learning process, there is one more factor; educational software, in general, is poorly related to the curriculum, its goals and philosophy, and the content to be covered. On the other hand, teachers need time and knowledge to evaluate the software and the learning activities to be used, to prepare new ICT-based activities and worksheets for their students etc. The software available in the schools should be accompanied by a complete teacher guide and a plethora of appropriate examples to be used in the classroom.

Lack of time: Lack of time produces negative attitudes to the teachers and does not help them to get involved in ICT-based activities. Integrating ICT into classrooms requires much more effort and time than regular teaching. Teachers need more time to plan their instructional choices and behaviors in the classroom, to design learning activities based on ICT, to locate information in the Internet, to prepare accurate ICT materials for their students, to explore and practice the resources needed etc. (Becta, 2004a). In general, they have little time left after school to experiment with technology, share experiences with colleagues, and attend in-service training programs. As Cuban, Kirkpatrick, and Peck (2001) found, the lack of time problem did not only apply to those teachers who made little use of

ICT in their lessons. Similar complaints were made by those teachers who were attempting to make full use of ICT in their lessons, as they had to work longer hours in order to achieve successful use of ICT.

Lack of technical support: Preparing efficient learning activities based on ICT tools demands that teachers' have the proper level of technical skills and knowledge. In most cases, technical problems are time-consuming and have a direct impact on teachers' confidence of using ICT in their instruction. Many teachers' certainly agree that technical support is needed in the schools (Becta, 2004), especially when things go wrong during their lessons. Lack of continuous technical support and fear about the breakdown of equipment inhibits teachers' of using ICT in their instruction (Jimoyiannis & Komis, 2004).

School Factors

Most teachers agree that computers constitute a valuable tool and are positive about students' achievement on ICT skills. On the other hand, although they recognize the importance of introducing ICT in education, they tend to be less positive about extensive use of ICT in their classroom and far less convinced about its potential to improve instruction (Russel et al., 2003; Waite, 2004). Stetson and Bagwell (1999) have analyzed the resistance of many schools, colleges, and departments of education to embrace technological applications into their methods of coursework.

Based on the results of their study, Sugar, Crawley, and Fine (2004) have outlined ICT adoption as a personal decision uninfluenced by other people and the presence of resources or impediments in the local school/district. Secondary education teachers considered *partnership* and *collaboration* with specialty colleagues and the other teachers in their school as a factor influencing their professional development towards integrating ICT in their instruction (Jimoyiannis & Komis, 2004). Granger, Morbey, Lotherington, Owston, and Wideman (2002) suggested structured collaboration and continuous communication among teachers as a factor contributing to the successful implementation of ICT in the schools.

Cuban et al. (2001) claimed the school itself, as an institute, is resistant to the changes needed for successful ICT integration and reorganisation in order to facilitate innovative practices involving ICT. It seems that the *school culture* and the general framework of schooling do not support teachers to integrate ICT in their teaching. Teachers' beliefs and perceptions are influenced by the many aspects of school practice and culture, which constitute a strong reason to reserve their traditional teaching practices (Munby et al., 2000; van Driel et al., 2001).

Research has shown that teachers with interest and motivation to learn about ICT use computers in a narrow range of applications, mainly, for personal purposes. Most of them continue to use ICT for low-level supplemental tasks, such as word processing (lesson plans, worksheets, assessment tests, registration of grades, etc.) or getting information from the Internet (Becker, 2000; OFSTED, 2004; Jimoyiannis & Komis, 2006a; Russel et al., 2003; Waite, 2004; Williams et al., 2000). Relatively few teachers use ICT routinely for instructional purposes and even fewer are integrating ICT into subject teaching in a way that motivates pupils, enriches learning and stimulates higher-order thinking and reasoning (Becta, 2004a).

As van Driel et al. (2001) pointed out teachers do not tend to risk changing their own practice which is rooted in *practical knowledge* built up over their teaching career. The concept of practical knowledge refers to the integrated set of knowledge, conceptions, beliefs and values teachers develop in the context of their teaching. It is influenced by various parameters, such as the profile of the teachers, the disciplinary background, the students, the school environment, and so forth. Consequently, practical knowledge constitutes the core of teachers' professionality, guides their actions in the classroom and, reasonably, acts as a negative factor to adopt ICT in their school practice. Teachers, in general, feel confident by using their practical knowledge which works in their everyday instruction very well, and are unwilling to change practices, teaching methods, habits or roles. Snoeyink & Ertmer (2001) have presented a teacher, not skilled on ICT, explaining her negative views of ICT on the basis that she wished to remain comfortable with her teaching. Similar results have also found in Greece where physics teachers seem to be unwilling to leave their "comfort context" of conventional subject practice activities (Siorenta, 2005).

Most of the teachers using ICT in their instruction are tentative to adapt new tools to their traditional teaching philosophies in such a way that makes them feel secure and confident. For example, they prefer demonstrating of computer simulations to support their lecture instead of engaging their students to pertinent ICT-based activities. Demetriadis et al. (2003) have found that teachers are interested in using ICT to take advantage of any possible learning benefits offered by ICT, but they appeared to cautiously adapt ICT usage to the traditional teacher-centered mode of teaching.

There is also a perceived tension between using ICT and the need to conform teaching to the external requirements of traditional examinations (Henessy et al., 2005). As far as the case of Greek schools concerns, there is another intervening factor which strongly influences teachers' attitudes towards ICT in education; the pressure from the national university entrance exams and the need to cover the set content of the core subjects (language and literature, history, mathematics, physics, chemistry, biology) prevail in teachers' instruction culture as well as in the students' learning culture. The following factors shape the negative impact that school culture induces on science teachers' perceptions about ICT in their instruction (Jimoyiannis & Siorenta, 2007):

- The traditional view of teaching as a process of knowledge transfer
- The need to cover the content set by the curriculum
- The restrictions posed by the science textbooks
- The need to practice their students on conventional (paper and pencil) problem solving tasks
- The requirement to prepare students for the final exams.

ICT Pedagogical Framework

Teachers' thinking and beliefs about teaching and learning are linked to what they do in their classroom and the choices they made in selecting how to integrate ICT into their instruction. A series of independent studies indicate that both teachers' personal theories and perceptions about teaching and learning and the level of competence with ICT play a major role in how they implement ICT and how they motivate themselves to use ICT tools in the classroom (Gobbo & Girardi, 2001; Niederhauser & Stoddart, 2001; Webb & Cox, 2004). Research findings also suggested that the majority of the teachers are aware of the ICT-related pedagogical perspectives and are skeptical about the difficulties they will face at in the classroom practice, for example to organize and manage students' ICT-based learning activities (Jimoyiannis & Komis, 2007).

Teachers' pedagogical cultures shape their representations of ICT use in the classroom (Ruthven, Hennessy, & Brindley, 2004), while they are likely to adopt practices with computers that reflect their beliefs about teaching and learning (Drenoyianni & Selwood, 1998). It has been shown that teachers with the most constructivist teaching philosophies regarded the role of computers in their instruction as very important (Becker, 2001; Ravitz, Becker, & Wong, 1999). Higgins and Moseley (2001) argued that the most effective teachers not only had a positive attitude towards ICT, but had also good ICT skills and used computers as a part of a stimulating environment favoring pupils' inquiry and collaboration.

It is commonly accepted that ICT can support students and teachers in accessing, organising, manipulating and displaying information in a totally different way. In practice, however, established curricula and teaching approaches still remain essentially unchanged, while technology is usually underused and poorly integrated into the classroom (Cuban, 2001; OFSTED, 2004). For example, applications such as simulations and modelling software, which have the potential to fundamentally change instruction and learning, are largely ignored because they are relevant to only a small part of the existing curricula.

Webb and Cox (2004) suggested that the use of ICT in the classroom is associated with a decrease in teacher direction and an increase in student control, self-regulation, and collaboration. The role of the teacher in classroom interactions does change alongside the integration of ICT in the curriculum. Consequently, teachers need be aware of the changing nature of teaching and learning associated with the introduction of ICT in the schools. Their efficient preparation should be addressed at adopting a *new pedagogy* and changing their behaviours and practices in the classroom. They need to shift from traditional lesson formats, based on transmitting information philosophies, towards student-centred approaches that promote active engagement, help students to control their learning, and support collaborative learning and meaningful understanding.

To increase the likelihood that computers will be used in the school practice, teachers need to be encouraged to try and acquire convincing experiences about the effectiveness of ICT on teaching and learning. It is critical that ICT should not be treated as a special

Table 1. Factors affecting teachers' views and perceptions of ICT in education

Personal factors
ICT competence, skills and training
Possession of PC and Internet connection line
Attitudes about using ICT
Perceived usefulness and ease of using ICT
Cautiousness about ICT in education
Perceived potential of ICT to improve teaching and learning
Resistance to changes
Teaching experience
Teaching subject and grade level
Age and gender differences
School factors
Resources or impediments in the school
Partnership and collaboration with other teachers
School practice and culture
School resistance to changes
Traditional teaching philosophies • Knowledge transfer approach • Need to prepare students for the final exams • Need to cover the content set by the curriculum • Restrictions posed by the textbooks • Need to practice students on conventional problem solving tasks • Use ICT for low-level supplemental tasks
Technical factors
Lack of ICT resources
Lack of appropriate software
Quality of the equipment available
Availability of the computer laboratory
Lack of time to prepare students' learning activities
Lack of time for training on ICT
Lack of technical support
ICT pedagogical factors
Awareness of the pedagogical characteristics and the potential of ICT
Pedagogical difficulties in organizing students' learning activities
Teachers' perceptions about teaching and learning
Lack of a wider pedagogical framework about ICT in education
Need to provide new ICT-based educational media
Need to establish a new ICT-enhanced curriculum
The changing nature of the pedagogical practices • Moving from teaching to learning • The new role of the teacher • Need for student-centred approaches

event or an extra tool to the traditional instruction. This means that ICT integration should be implemented in the context of broader instructional reforms aiming at the *curriculum*, the *educational media* and, principally, at the *pedagogical practices* used. Professional and preservice teacher development programs should focus on coupling changes in teachers' pedagogical cultures and philosophies with their training on how to use appropriate ICT tools with their students.

Table 1 incorporates a brief presentation of the many factors affecting teachers' views and perceptions of ICT in education.

SUMMARY AND DISCUSSION

ICT integration in the classroom practice is a complex and multifaceted issue. Marginal use of ICT will obviously cause no outcome for the students. Teachers should be confident and competent with a range of ICT applications to support their teaching and their students' learning. Moreover, they should become more aware of the value and the potential of ICT as a tool for lifelong learning, for their students as well as themselves. They need to understand how ICT can be integrated into everyday practices and how their students should be engaged into appropriate ICT-based learning activities.

This suggests that teachers should be able not only to use ICT for personal purposes or to support their traditional instruction, but also mainly to reorganize their instruction by using ICT. Effective programs aiming at teachers' ICT preparation and support should be flexible, continuous, and focused on the subject-matter pedagogy (Jimoyiannis & Komis, 2006a). They should clearly articulate specific types of efficient instructional models and representative ICT paradigms for every subject in the curriculum. Appropriate teachers' support and guidance should take account of their different levels of ICT skills, their subject (curriculum and educational recourses), and also their professional development targets.

Teacher advances in technology integration occur slowly and proceed through distinctive stages (Liu & Huang, 2005; Rogers, 1995; Russel, 1995; Sherry, 1998), where the highest stages require changes in attitudes more so than skills (Knezek & Christensen, 2000). The critical point for the educational authorities is to conceive ICT use in education in terms of specific *pedagogical dimensions* rather than a single technological dimension. ICT integration plans and programs should be developed in a wider context of *school improvement*, *curriculum reform* and *teachers' professional development*. Top-down imposed policy decisions and technocentric models for ICT adoption appear to be unresponsive to the teachers' perspectives, priorities, and their classroom or professional needs also (Jimoyiannis & Komis, 2006a). Future policies concerning ICT in education should principally be addressed to an integrated framework, where the following issues are of great importance (Jimoyiannis & Komis, 2007):

- Helping teachers to adopt ICT not as a trend in our modern technological society but as an *efficient teaching and learning tool*.
- Encouraging teachers to develop a new *educational culture* by integrating *self-development* on ICT in education into their professional development planning.
- Creating and supporting powerful teacher *communities of knowledge and practice* by providing continuous training, support, communication, and knowledge interchange, on both pedagogical and technological issues.

There are still a lot of parameters to be identified about the way teachers perceive ICT in education and the practices followed when they use computers in their classrooms. Future research should be addressed at investigating:

- The best practices that influence teachers' adoption of and students' achievement through ICT-based learning environments
- How and why subject cultures differentially affect students' perceptions and uses of ICT as a learning tool
- The educational policy factors that affect the continuation and institutionalization of the changes induced in the schools by the integration of ICT.

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KEYWORDS

ICT Adoption Factors: The factors affecting teachers' perceptions of ICT in education are divided into four categories: personal factors, technical barriers, school factors, and pedagogical factors.

ICT in Education: This term refers to the various aspects of computes, networks (including the Internet), software and other environments that act as a tool for teachers and students by supporting learning and instruction. ICT implementation in education is a complex and multifaceted process and, till now, many difficulties encountered to integrate ICT in the school practices.

ICT Integration: The integration of ICT in the school practice has not to do with simple improvements of the traditional instruction but to a radically new pedagogy; shift from the traditional instruction model of knowledge transmitting towards autonomous, active, and collaborative learning through students' engagement in ICT-based learning environments and shared learning resources.

ICT Pedagogy: The effective integration of ICT alongside the curriculum is associated with a new pedagogy which changes the role of the teachers and increases students' control of their learning, self-regulation, and collaboration. This presupposes a shift from traditional lesson formats, based on transmitting information philosophies, towards student-centred approaches that promote active engagement, help them to control their learning, and support collaborative learning and meaningful understanding.

Teachers' Attitudes: Teachers' attitudes toward ICT constitute a multidimensional variable. In general, attitudes toward ICT incorporate self-efficacy, confidence, and ability of using ICT, beliefs, ideas, and perceptions of the many aspects that ICT brings education.

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Fostering Collaboration in CSCL

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INTRODUCTION

Some collaborative learning strategies widely used in face-to-face settings can also be adapted to online contexts. They allow us to master the complex relations between members of large, heterogeneous online learning communities. The authors build on their experience in the application of some of the most well-known strategies and techniques used in online courses, such as jigsaw, peer review, role-play, case study, and brainstorming. The use of these strategies in computer supported collaborative learning (CSCL) environments and the related models describing the social structure of the learning community is discussed in the attempt to highlight their strengths and weaknesses and investigate the conditions for their applicability. The aim is to inform the design and the management of online learning communities.

BACKGROUND

The theoretical framework of this study is based on:

- Socioconstructivism, which emphasises negotiation as the basic element in the process of knowledge development and considers language, dialogue, and collaboration as the main learning tools (Vygotsky, 1934/1962);
- Situated learning, that stresses the importance of the cultural and social context where learning takes place, since this context is strictly intertwined with the knowledge development process (Brown, Collins, & Duguid, 1989);
- Computer supported collaborative learning (CSCL), according to which computer mediated communication and, in particular, written, asynchronous interactions between the members of a virtual community favour the development of critical thinking and conceptualisation (Dillenbourg, 1999; Palloff & Pratt, 1999).

In this framework, online learning initiatives generally include methods and activities that promote interaction, negotiation of meanings, and collaborative construction of knowledge within authentic and meaningful contexts. The learning community, meaning all the actors involved, plays a prominent part in the process. Several different roles can be identified: the designer, the tutor, the expert of the domain, and, obviously, the student. Although the differentiation of roles helps both the design and the critical analysis of the learning process, a single actor may play more than one role. It is, in fact, desirable that all the community members share their competence and play an active and proactive role in the management of the learning process.

During the course, it is desirable for community members to interact, discuss, and participate in the production of cognitive artefacts. In order to facilitate and encourage these collaborative dynamics, strategies and techniques that support the development of the social dimension of the community are often used. These strategies are selected by the designer prior to the educational process, taking into consideration a number of variables such as course objectives and content, characteristics of target population, and context constraints. For this reason, different courses use different strategies and each strategy requires a suitable "social structure." The concept of social structure includes team composition, roles, and relationships between team members as well as relationships between teams. Indeed, teams may vary over time during a course and even within the same activity while each strategy requires team members to play distinct roles (Persico & Sarti, 2005).

STRATEGIES AND TECHNIQUES TO FOSTER COLLABORATION

The terms “strategy” and “technique” are sometimes used to indicate explicit and complete procedures. At other times, they identify mere expedients. In any case, they serve the purpose to organize and guide students’ collaborative activities in order to help them meet the desired objectives. As far as our study is concerned, the two terms are practically synonyms: the former emphasises the importance of the organisation and management of the learning activity, and the latter stresses the procedural nature of the method. Each technique is generally described in terms of the steps of a procedure and the behaviours that students are supposed to put into practice. Some examples are Jigsaw, peer review, brainstorming, case study, and role play. Although they have been borrowed from in-presence collaborative contexts, these techniques have also proved effective in online learning. Indeed, virtual environments have features that often enhance the pedagogical potential offered by such techniques: for example, the possibility of interaction independent of time and space and the chance to reflect on contributions to the discussion thanks to the permanent nature of computer mediated dialogues. The above mentioned strategies have been given different names by different authors: “cooperative and competitive learning structures” (Kagan, 1990), “instructional methods” (Kanuka & Anderson, 1999), “techniques” (Aronson, Blaney, Stephin, Sikes, & Snapp, 1978), and “collaborative learning flow pattern” (Hernandez-Leo, Asensio-Pérez, Dimitriadis, Bote-Lorenzo, Jorrín-Abellán, & Villasclaras-Fernández, 2005). Dillenbourg (2002) introduces the expression “CSCL scripts” and states: “*A script is a story or scenario that the students and tutors have to play as actors play a movie script.*” Unlike cinema, however, the designer is like a director who has only a rough idea of event sequencing and leaves to the creativity of the actors (learners and tutors) not only the details but also some important decisions regarding the script, the actors’ roles, and often even the aims of the performance. Each phase of the script specifies how students should interact to solve a given problem through a collaborative activity. Hence, the script includes five elements: the student’s task, the group composition, how the task is distributed within the group and sometimes between groups, the type of interaction both in and outside the groups, and the schedule of phases, if any.

Even if every technique is different, they do have some features in common. For example, most of them are based on a “learning by doing” approach, where the exchange of opinions among peers is favoured by proposing tasks in which the final aim is either the creation of an authentic product (artefact) or the solution of a real problem. The underlying idea is that the need to attain a common and tangible objective activates concentration and is a catalyst for the participants’ efforts. Of course, students will need to fully understand the techniques adopted, and, to achieve such mastery, procedures and instructions should be stated very clearly (Brush, 1998).

Most strategies to support online collaborative learning feature two or more stages in order to allow participants to collaborate at different levels and differentiate among roles, thus favouring the adoption of multiple perspectives. Groups are generally small (5–7 people) although some strategies feature multilevel grouping: for example, small groups in the first stage and the whole cohort in the second stage. A useful rule of thumb is that small groups are preferable for more structured activities, while brainstorming and free discussion are more effective in larger groups. Small groups have the following advantages: individual participants have more opportunities to contribute to the discussion, decision making is faster, people get to know each other better and reach agreement more easily. Larger groups, on the other hand, bring in more people to accomplish a task, more ideas, and a broader range of skills. They also provide more opportunities for participants to refer to what has been said by others. In any case, the possibility to alternate different kinds of grouping allows instructional designers to take advantage of the strengths of both small and large teams. Table 1 compares the above-mentioned strategies, reporting some critical aspects that usually inform decision making in instructional design.

Studies concerning the adoption of group techniques in CSCL show that there are conditions to their effectiveness (Blocher, 2005; Hinze, Bischoff, & Blakowski, 2002; Lebaron & Miller, 2005; Renner, 1997). One important prerequisite for all collaborative techniques is that they should promote reciprocal interdependency of participants. This means that teamwork should rely

Table 1. Comparison of some well known strategies

	Target population	*Time*	*Structure of communication environment*	*Comments*
Jigsaw	Does not lend itself to the management of big groups of students, due to the complexity of the approach.	Time consuming: both phases need time. It is not advisable to use it for the first activity of a course: people need a good degree of familiarization with their peers, the learning environment, and mediated communication	Each group needs two discussion forums, one for the first phase and one for the second.	Allows a cooperative approach, that is, based on task share-out. As a consequence, it does not always obtain a fully fledged collaborative process, where people work together to achieve a common aim.
Peer Review	Allows for large student numbers, as each one actually interacts with a small number of fellow students (however, tutor workload is high, unless tutor feedback is not given on every piece of work). Particularly suitable for adult education. Unfit as an initial activity of a course, as people need a certain degree of familiarization with their peers to provide feedback without embarrassment.	Depends on the task complexity. However, the method is well-known and simple to apply: in general it is not particularly time consuming.	Depends on the structure of the feedback mechanism. If it is in pairs, at least one forum for each pair is needed. For more complex structures, the simplest solution is to set up a forum for each artifact produced in the first phase.	A very critical aspect is the presence and quality of feedback. When students receive very poor feedback, or even no feedback at all, the quality of subsequent work is at risk and greater tutor support is needed. Another crucial aspect is related to the capacity of people to positively interpret criticism by others.
Role Play	Allows for easy management of heterogeneous populations. Some authors believe the roles should not closely reflect the participants attitudes: it is better to let people identify themselves with other perspectives.	Not particularly time-consuming. The choice of roles, however, might take up some time; a useful trick to avoid this is to assign roles to participants, rather than let them choose.	Usually a single forum is set up for each group. However, when many participants play the same role, they should get a privileged communication channel.	Responsibilities are balanced and it is possible to make the most of everybody's aptitudes. Can be used together with the case study.
Case Study	No particular constraint is imposed on the size of the target population, even if the organization and management of the discussion groups may heavily depend on it. It puts to good use possible differences in competence and background. Particularly suitable for adult education	Depends on the complexity of the case to be studied and on the size of the population.	Usually a forum is set up for each discussion group.	Work must be truly collaborative, cooperation is not enough. Expert solutions should not be made available from the beginning, but only at the end, to allow comparison with those elaborated by the participants.
Brainstorming	It is suitable for large groups and makes full use of the diversity in competences.	It increases respect for other people's ideas and encourages active listening. As a consequence, it fosters the emergence of a positive sense of community and lends itself to the initial phases of a learning activity.	Usually two forums are set up, one for the divergent phase, and the other for the convergent one.	It can be used to break the ice in a case study.

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heavily on the contributions of all the members. Interdependence of participants can be achieved in different ways, usually by exploiting the nature of the task and of the content. This happens, for example, when the final product of the learning activity is like a puzzle whose pieces are the products of individual or small group work and need to be integrated with the other pieces to come up with something that makes sense. Another way to promote a fruitful reciprocal interdependency is when there is a common motivation (e.g., a prize) or even a competition against other teams. Alternatively, role play strategies can be used to encourage participants to analyse a problem from different, and possibly complementary, viewpoints (Renner, 1997).

Hinze et al. (2002) experimented with the Jigsaw method in the CSCL context and claim that this method inherently enforces the interdependence of group members, favours the adoption of multiple perspectives, and fosters team teaching. However, they also pointed out three important conditions that should be fulfilled for this technique to be effective. The first condition is a good degree of group cohesion that can be achieved either face-to-face or with suitable "getting-to-know" games/activities at the beginning of the learning process. The second is a reasonably high level of individual self-regulation and a full awareness of the tasks to be carried out: this points to the need to strike a balance between leaving students free to organise their own learning and providing them with guidance. When individual skills and competences are very heterogeneous, some students might need more tutoring and virtually "on demand" support while others might appreciate the freedom to decide how to organise their own learning. The third condition has to do with the time framework required for communication, cooperation, and coordination online. Trainers who are used to facilitating face-to-face learning may easily underestimate the time needed to achieve online collaboration. It is believed that online techniques often generate deeper learning processes, but there is simply no comparison between the time needed for a discussion online and a similar one face-to-face, especially where asynchronous communication is concerned. Although these considerations emerged from a study of Jigsaw online, they appear to suit most of the techniques that can be used online. However, more research should be carried out to provide instructional designers with solid and systematic methodological guidelines for the implementation of collaborative learning techniques online.

CONCLUSION AND FUTURE DEVELOPMENTS

The strategies and techniques addressed in this article allow designers to organise authentic and meaningful activities, manage the complexity of the topics at hand, and solve problems related to the number and heterogeneity of participants in a learning community. Similarly to what happens in face-to-face contexts, appropriately designed strategies and their social structures can be the trigger to fruitful learning dynamics, provided that they succeed in taking advantage of individual diversity, of the wealth of didactic materials, and of the negotiation of meanings, which are the typical ingredients of socioconstructivist learning processes. Decisions about what strategy best suits a given context are based on heuristic considerations that take into account the different features of the various techniques, as summarised in Table 1. To make the instructional design process as systematic as possible, formalisms that explicitly represent the structure, the organisation, the planning, and, in general, the strategic decisions taken by the e-learning designer have been investigated (Koper, 2001; Koper & Tattersall, 2005). This field of study, called learning design, has led to the definition of models and languages which can support the description and design of the typical dynamics of a learning process. These also allow the best design practices to be represented, saved, transferred, shared, and reused, thus promoting awareness of the importance of organizational aspects, both at a temporal level (duration, sequence, alternative, or optional paths) and at a social level (group formation, role differentiation, learning workflow).

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KEY TERMS

Brainstorming: A group technique aimed at enhancing the creativity and the production of new ideas; it is very useful for finding solutions to problems when the traditional approach seems to be unsatisfactory. Participants start talking about a topic or a real problem and they are asked to share their opinions freely so that everyone is able to express ideas linked to those already stated. Brainstorming can be carried out orally or in a written form, face-to face or online, and is usually moderated. The technique includes two phases; the first one is divergent, where the production of new ideas is stimulated for a fixed period of time; the moderator invites the participants not to pass judgment or to criticise and tries to enhance the discussion flow. The second phase, the so-called convergent phase, is aimed at selecting and evaluating ideas so as to identify and share the most interesting ones.

Case Study: A technique based on a problem-based approach. During a case study, students are provided with materials describing a concrete, authentic experience and are asked to critically analyze the case. Often, learners are asked to propose or collaboratively define a possible solution for the examined case, describing the reasons for their choices, and afterwards, they have the possibility to compare their solution to the one adopted in the real case by experts. As case studies are based on real problems, they represent a strong link between theory and practice. Furthermore, case studies are narrative forms of thinking as opposed to abstraction and generalization. For these reasons, case studies are particularly suitable for adult education, or in any situation where the ability to critically reflect upon experience is highly developed.

Jigsaw: Suitable when the subject matter is particularly complex but easily fragmented or analyzed from different perspectives. It envisages two phases: during the first phase each of the so-called "expert groups" have to investigate a different aspect of the complex topic. In the second phase, new groups are formed, called "jigsaw groups," each of them composed of one representative from each of the expert groups. Within the jigsaw group, each student is asked to contribute his/her experience to the rest of the group, so that at the end all groups get a complete overview of the topic. Usually, jigsaw groups have to produce an oral or written presentation, but any other artifact can be chosen if it is able to provide an overall view of the topic.

Peer Review: Based on a critical analysis by learners of a product previously realized by peers. Usually the process includes three phases: during the first stage, learners are in charge of producing an artifact (a document, map, hypertext, etc.); in the second stage, they are asked to provide feedback to the work done by their colleagues; during the third phase, learners are asked to revise their original product on the basis of the received feedback. During the peer review, a reciprocal teaching approach is stressed, where one's own interpretation of reality is to be compared with that of others. Unlike the Jigsaw technique, peer review is not associated with a specific social structure per se and can be orchestrated in different ways so that the reciprocal feedback can be provided either at the individual level or by pairs or even among groups. Furthermore, the review process may be organized in several ways: networked (any entity may provide feedback to any other entity), cyclical (entity A provides feedback to entity B, B to C, C to D, etc.), or reciprocal (entity A provides feedback to entity B, which in turns provides feedback to A).

Role Play: This technique allows learners to "play a role" in order to assume a particular point of view during discussion with colleagues. In online courses, the students are usually asked to analyze materials or documents from a particular perspective and to have a discussion with other members of the group and reach an agreement, maintaining all the while the standpoint of their assigned role. Role play allows responsibility to be distributed between the participants and to take advantage of their individual attitudes, while promoting reciprocal interdependence. Authors from the radical constructivist approach claim that the role play technique can be used to "*insert a slice of life into the classroom, connect theory with everyday practice, practice unfamiliar skills in a safe setting, and learn to appreciate contradictory viewpoints*" (Renner, 1997).

GIS Use in Landscape Archaeology

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INTRODUCTION

Information technologies (ITs) entered and irreversibly changed the discipline of archaeology during the last 20 years of the second millennium. The first experiments involved databases and alphanumeric data processing, then in the late 1980s GPS technologies, associated with spatial data processing, were first tested to locate archaeological objects in the geographical space. Computer-aided design (CAD) software has progressively replaced the traditional procedures of topographical and architectural design, while "New Archaeology" and "Processual Archaeology" focusing their attention on the quantitative aspects of phenomena (Binford, 1989; Binford & Binford, 1968; Clarke, 1968; Clarke, 1977) adopted "spatial technologies", consisting of computer-based applications concerned with the acquisition, storage and manipulation of spatial information (Wheatley & Gillings, 2002).

This process came along with the elaboration of the new concept of "cultural heritage", which gained popularity among specialists as well as among the general public. Since then, artifacts and monuments are no longer considered the only objects to preserve, and they are not extrapolated from their geographical context anymore, but every trace that the past has left in our environment is seen as a unique testimony of our history.

To understand cultural landscapes in their diachronic evolution it is essential to find an efficient system to store all archaeological and ecological information in a suitable way, so as to examine vertical and horizontal relations between different archaeological sites and other landscape features, like geomorphologic setting, hydrological assets, soil types, raw materials availability, and so forth, in time and space. This instrument has been found in geographic information systems (GIS), defined as a set of computer-based applications aimed at storing, transforming, manipulating and analyzing spatially distributed data. The development of these systems began around 1980. They were used in many fields concerned with mapping, analysis and modeling of spatial data, including geology, geography, and environmental sciences (Douglas & Boyle, 1982; Evans & Daly, 2006).

The introduction of GIS technologies in historical sciences and in cultural heritage management (known as well as cultural resources management "CRM") has supplied the society of knowledge with a formidable instrument to fully understand the evolution of its habitat and to preserve its environmental and historical patrimony.

The impact of these ITs in our discipline has been so powerful that an animated debate is still going on about whether GIS should be considered as just a tool or whether it is a science in its own right (Conolly & Lake, 2006; Wright et al., 1997). Periodical as well as occasional meetings, congresses, workshops, and conferences take place regularly all over the world, and more and more specialized series of volumes and periodicals are being published in traditional or electronic form, about the relationship between archaeology and computers, or more specifically about GIS in archaeology (e.g., the Proceedings of the Annual Conferences on *Computer Applications and Quantitative Methods in Archaeology*, edited in the BAR International Series; the Journal of GIS in Archaeology on the ESRI Website: www.esri.com/library/journals/archaeology). Still, in spite of the fact that new GIS products are available on the market almost every day, and that the existing software is continuously implemented and updated, notwithstanding that new and more complete manuals on digital archaeology are regularly edited, we could state that the basic deontology of the discipline has been defined and the correctness of basic procedures fixed. This also means that the most updated or recent achievements or studies are not always to be considered as a substantial contribution to the literature and a progress of the discipline.

The goal of this article is therefore to review a series of GIS-based archaeological projects, presenting different approaches and results, mostly taken from the geographical context of southern Europe, and to try to evaluate, in an objective way, which are the pros and cons, and the problems involved. Instead of presenting just one case study, we prefer to refer to a selection of good examples and some personal experience.

BACKGROUND

The first historical accounts for the use of GIS in archaeology date back to the early 1990s, but experimental applications of GIS in archaeology were undertaken already in the mid-1980's in the USA (Allen, Green, & Zubrow, 1990; Harris, 1986; Kvamme, 1983; Lock & Stančič, 1995), with a dominant interest for Cultural Resources Management, while some of the first European experiences in the late 1980's were already approaching landscape analysis (Lock, 2003; Lock & Stančič, 1995). Over the last few years the applications have developed spectacularly, both in the availability and capabilities of software, and in the quantity of relevant projects and case studies (Berger, Bertoncello, Braemer, Davtian, & Gazenbeek, 2005; Forte, 2005; Gillings & Alii, 1999; Lock, 2000; Petrie, Johnson, Cullen, & Kvamme, 1995; Slapszak & Stančič, 2000).

As stated earlier, this increasing importance is partially due to the development of the concept of "cultural heritage," extended now to include cultural landscapes, and to the more widespread interdisciplinary approach that landscape archaeology has embraced, adopting methods and instruments from geography, geology, earth sciences, information technologies, topography, remote sensing, geo-physics, spatial analysis, and so forth. Nowadays it seems almost impossible, and surely outdated, to tackle archaeological matters without the support of a GIS, but unfortunately the growth in availability of GIS technologies has not always been associated with a parallel increase in the knowledge and technical skills of archaeologists.

GIS IN ARCHAEOLOGY

The innovation and the power of GIS lie in the capacity to link mapped objects to a database, combining the graphical display of archaeological records with database query and analysis tools. Archaeological elements can be examined in their spatial distribution, related and overlapped to environmental factors, such as soil type and quality, land suitability for agriculture and stock raising, micro-climate aspects, and so forth, in order to determine which environmental factors most influenced human occupation patterns, and to develop a diachronic model of habitat for each phase.

The archaeological map production within a GIS environment has enormous potential for combining disparate data sources: archaeological data, topographic information and historical cartography, satellite images, aerial photographs, orthophotomaps, administrative boundaries and cadastral maps, urbanization areas, soil type and geological maps, hydrology and water resources. This is the crucial point—a GIS differs radically from a computer-aided cartography production system (CAM = computer-aided mapping), because it stores information "thematically" (Wheatley & Gillings, 2002, pp. 25-28). By way of comparison, a geographical or topographical map contains a wide range of data related to many different aspects of the present landscape, and links elements of the natural morphology (slope, hydrology, soil quality and geology) to the elements connected with the human presence (road-networks, waterways, buildings, agricultural land-use, political boundaries, etc.). Instead, GIS stores different levels of information in different layers, that can be overlapped selectively—they can be "turned on or off", according to the query being pursued. Thematic maps are then produced without the problems normally connected with the many different scales and projections of the data sources (Cowen, 1987).

The research undertaken by the University of Cassino (Italy) and the University of Ghent (Belgium) in Corsica, in and around the Roman town of *Mariana*, is a case study for some of the possibilities that such an integrated work can offer for field archaeology. Here the historical and archive data, historical maps, old and present day cadastral maps, old site plans and early aerial photographs are integrated with data from recent field survey, geomorphologic observations, geological and soil maps, oblique aerial photography, geophysical research and excavations (Corsi & Vermeulen, 2007). The overlaying of all these data, spatially referenced in the GIS, allows us to deeply evaluate the stratigraphy of rural and urban landscape, to identify much information on the monumental setting of the town and its street network, to recover many elements of the ancient land division and location of Roman farms, to detect the role of landmarks and to answer the main research questions. The first of these is concerned with a reconstruction of the ancient landscape around *Mariana*. The second question is more specific and concerns the precise location and especially the extent of the Roman town, while the study of the intra-mural urban patterns, such as roads, public space, location and character of housing, is the subject of the third theme of research.

As elaborated applications of GIS in the field of archaeology date back more than 15 years, the approaches vary considerably. In most of the projects, GIS are applied using existing products, selected from among the wide variety available, on the basis of the characteristics and specificities of the software—mainly the ODBC data sources to link databases—and the methodology and scientific approach of the project. In a few cases, GIS software is specifically elaborated for archaeological mapping (Evans & Daly, 2006; Lock, 2000). Integration of methodologies guarantees in all these products the essential link between the database with different formats of information (text, image, multimedia) and the different types of spatially referenced cartographies, stored both in raster or vector format.

The most classical application of a GIS is therefore its use as an instrument to store and manage a huge amount of data, spread over large geographical areas, where rapid queries, sorting and presentation of results are easily accessible, keeping the option of zooming and scanning across the map to a particular area of interest. This use is essential in cultural resource management (CRM), a society-based application that needs to know what archaeology is where (Lock, 1998). GIS will also supply specialists with a wide array of tools for the documentation and analysis of archaeological excavations. Computer technologies can be of great help in mapping archaeological features or artifacts distribution and in combining disparate data-recording systems, such as detailed trench plans and architectural drawings. Therefore all the institutions devoted to cultural heritage preservation ought to acquire efficient systems that are easy to handle, implement, and interrogate.

This approach allows procedures for analysis as well as for presentation of scientific results, both at the specialist level and for the wider audience (Djindjian, 1998; García Sanjuán & Weateley, 2002). In this respect, the GIS application performed in the *Caere Project*, focused around the Etruscan town and necropolis of ancient *Caere*, in Italy, just north of Rome, remains a very good example of integration between scientific research and GIS Web presentation. The main focus of the *Caere Project* is to enable user interaction through the Internet, by offering the possibility of querying the excavation plans at any scale, starting either from the cartographic data or the textual information contained in the excavation diaries. The system has a client-server architecture that also requires middleware—a program that sends the processed data from the server to a client for whom no processing is necessary. Initially developed for use on an intranet, with access provided only to specialists working on the project, the system has been transformed into an online GIS, by mean of the use of the software package MapGuide 5 (®Autodesk) (Kvamme, 1998; Moscati, 2002; Moscati & Tagliamonte, 2002).

The introduction of GIS integrated technologies has also radically affected the methodology of landscape archaeology in the different stages of a research project. In fact, some aspects of these research activities are now requested to be more objectively, almost mathematically based, primarily in the selection of the areas that will be surveyed as relevant samples, and essentially during the process of field data recording (Johnson & MacLaren North, 1997; Wheatley & Gillings, 2002). Starting from the most basic operations, the location of the archaeological record on the terrain has to be very accurately registered and spatially referenced with coordinates in the agreed projection system, in most cases with a GPS instrument (Vermeulen, De Dapper, & Brackman, 1998).

Even more drastically, the manipulation and analysis tools for spatial data that constitute the defining characteristics of a GIS have affected the methodology for investigating spatial distribution of phenomena and have generated a dramatic change in the traditional approaches to exploring spatial patterns and relationships. In practice, with GIS, the evaluation of certain historical aspects and trends relies not only upon distribution maps elaborated just by sorting information from the database or with the support of mathematic and statistical methods for spatial analysis, but implies computer-aided data processing that can integrate many more levels of information (Ebert, Camilli, & Berman, 1996).

ICTs are being employed to make archaeology accessible to the general public and the possibility of performing interactive queries and making use of multimedia databases has been exploited to sensibly increase the effectiveness of communication and to deepen the understanding process (Lock, 2003, pp. 219-230). For instance, 3D digital terrain models (DTM) and digital elevation models (DEM) of the landscape can be created by digitalizing the map contour lines. These more immediate models can be very helpful in understanding the topography of a region and in its evolution through the ages, for specialists as well as non-specialists (Johnson & MacLaren North, 1997; Raper & Kelk, 1991), making it possible to correlate site locations with the environmental variables and facilitating further analyses.

FUTURE TRENDS: ANALYZING AND SIMULATING THE GEOMORPHOLOGICAL AND THE CULTURAL LANDSCAPES

The preceding review has briefly presented a selection of the more significant ways in which GIS have effected landscape archaeology, and will continue to in the near future as the full potential of these systems has not yet been totally prospected (Johnson & MacLaren North, 1997; Wheatley & Gillings, 2002).

Among analytical tools available in a modern GIS, surface and elevation modeling is the one that is gaining the greatest attention and catalyzing the most spectacular development in the very near future. Digital Elevation Models (DEM) can be constructed using secondary data sources (digitized contour lines and spot heights derived from topographical maps) and/or primary sources such as GPS data, topographical field measurement work and LIDAR survey. Applications of surface modeling can be divided into two main groups, distinguished on the basis of the main goals of an archaeological GIS, termed usually as “Management-purposed” GIS or “Research functional” GIS.

Landscape Visualization

As pointed out previously, GIS technologies can be implemented to allow the computer to create a surrogate visual representation of an extinct landscape. These applications, already quite sophisticated and often very realistic, play an increasingly important role in presenting the past to the public. Tools to produce 3D images of reconstructed landscapes are often available in GIS software, and their use is more and more feasible. This possibility of visually and virtually recreating a rural or an urban landscape or a monumental scene can be exploited in the CRM contexts as in the scientific analysis process, better evidencing and displaying the complexity of different matrix factors and the interactions of levels, but it is mostly used to explore the relationships of visibility and intervisibility among selected archaeological locations in the landscape (Loots, 1997, for a case study of this application in Sagalassos, Turkey).

Archaeological Site Modeling

The possibility of creating 3D reconstructions of monuments and sites is certainly helpful as visual illustration (Voorrips, 1997). Virtual visits of sites have become quite normal in tourism, in web-surfing and more recently in teaching and computer-assisted learning (Campbell, 1995; Garfield & McDonough, 1997; Lock, 2006). Still, the most innovative use of Archaeological Site Modeling and CAD technologies can be identified in the possibility of a deeper comprehension of ancient structures and sites and the opportunity of recreating the forms of ruined domestic structures and the morphology of ancient settlements (Sanders & Sanders, 2000). Architectural planning, building techniques, structural characteristics, materials resistance, damage location and deterioration trends can be visualized, tested, and monitored in the easiest and most efficient way.

Line-of-Sight and Exposition Analysis

Among the more innovative possibilities of settlement patterns analysis in a GIS environment, are the exposition and the line-of-sight (or visibility: Wheatley & Gillings, 2002, pp. 201-216 for an excursus on first applications and recent presentations) analysis. Thanks to the digitalization of maps contours and the elaboration of DTMs, in fact, it is possible to determine which orientation ancient settlements have chosen to establish themselves in the landscape and what was visible from any given location. Comprehension of such factors is essential in reconstructing military landscapes and the “geography of power”. It is proven, for instance, that the old Celtic road network connecting the hill forts of some areas in ancient Gaul were essentially within the line-of-sight of the hill forts, rather than along more direct paths (Madry & Rakos, 1996).

Predictive Modeling

One of the most exploited applications of GIS, mainly in the context of cultural resource management (CRM), is the construction of "predictive models" (Veljanovski & Stančič, 2006). Next to the generation of predictive maps for land managers and developers, this method aims to generate a spatial model that has prognostic implications for further observations, and can assist fieldwork and distribution data processing (Kvamme, 1990, p. 261; Wheatley, 2003/2004, with a critical methodological review). Practically, when applied in archaeological research, these models concur in constructing hypotheses where the location of the known presence of archaeological features is utilized to predict the possible distribution of ancient settlements and therefore restrict the areas of investigation or select the areas subjected to limits in modern exploitation (urbanization and industrial building, quarrying, mining, high impact agricultural exploitation, etc.). Predictive modeling techniques available within GIS software have actually been successfully applied to design probability models for the distribution of ancient sites, and they have supplied archaeologists with a wider panorama of data for the total area under study and not only for the excavated surfaces or the surveyed set of samples (Westcott & Brandon, 2000).

CONCLUSION

Reviewing the literature and hundreds of case studies, we can state that GIS technologies have substantially aided archaeologists in reconstructing and understanding cultural landscapes much altered by morphological transformations and millennia of human interference. These valuable acquisitions have been possible thanks to the integration of different instruments and methodologies of research in the humanities, geography, earth sciences, information technologies, topography, remote sensing, statistics and applied geo-physical technologies. The introduction of Information Technologies in the human and historical sciences has surely brought an increase in speed, accuracy and efficiency in archaeological mapping.

In summary, the introduction of GIS in archaeology has involved:

- A revolution in and a drastic revision of sampling strategies adopted in archaeological survey. The actual practice of recording and representing archaeological data has taken into account the standards of ICT and digital techniques, meaning a more systematic data collection.
- An advancement in the use of quantitative methods in archaeology, with a more elaborated data processing, especially in performing the most complex spatial analysis.
- A undoubted improvement in the immediate visualization of interaction between mankind and environment through time, powered by 3D tools, that give also easy access to historical landscapes exploration.
- Access to the World Wide Web (the Internet) has transformed the ITs applied to archaeology into real information communication technologies, increasing vertically the dissemination of information to both professionals and the public. Digital Archaeology undertook online publication using the Internet in the 1990's: first aborted experiments of online journals have been replaced by a wide offering of fully-refereed online periodicals (*Internet Archaeology* being the first in 1996, http://intarch.ac.uk/) (Richards, 2006). To publish and disseminate archaeological GIS on the Internet, the elaboration of new server-based platforms was needed, and several solutions have been offered, mostly built on accepted standards that enable organizations to publish and share geographical maps, data, models, and more.

However, applying GIS in landscape studies is not without problems, nor dangers. In respect of every automatic technology, it is the quality of the information introduced into the system that requires the most careful tests and the most critical examination. It is important not to forget that the interpretations of these data will be only as good as the questions asked (Vermeulen, 2000; Wheatley, 2003/2004). While 15 years ago, many scholars in Archaeology had hardly heard about GIS, nowadays almost every project claims to utilize it. The decrease in product prices and in the complexity of instruments and hardware requirements, however, did not always correspond to a growth of knowledge and technical skills of archaeologists using the system. The results, given the ignorance in data-recording procedures and the under-estimation of technology's limits, have often been constructions of computer-based systems that are not historically based and that cannot be used either in understanding or in preserving cultural landscapes because of their "poorly documented resources and misleading conclusions" (Wheatley & Gillings, 2002).

With Conolly and Lake (2006), we can admit "the study of GIS has now matured to the point where non-specialists can take advantage of relatively user-friendly software to help them solve real archaeological problems... Nevertheless, the widespread adoption of GIS brings with it several dangers. The most problematic is that modern GIS packages offer users a variety of powerful tools that are easily applied, without providing much guidance on their appropriateness for the data or the question at hand."

Once again, the error could be identified in the misunderstanding of qualifying instruments of research as the "final objective" of the research. In Landscape Archaeology, as well as in many other disciplines, computer-based applications should be used to acquire, process, present and transfer knowledge, in our case history-based knowledge, but they cannot replace the solidity of individual experience, correctness of the methodology and tightness in the critical principles of the research. The basic value of this methodology should not be called into question, however, as the introduction of GIS has given us an extraordinary instrument to understand past processes comprehensively and, in time, to explain them better (Vermeulen, 2000).

All the projects selected in this presentation and so briefly framed above have this in common: GIS has been treated as "just one tool—albeit one very powerful one—among the many that may be deployed for archaeological purposes' (Conolly & Lake, 2006), and it will now be clear that this is our position too.

The introduction of GIS in landscape archaeology, as in other fields, has created opportunities and posed obstacles. Increasing costs of equipment *vs.* less resources for active research, more technical skills required *versus* a solid classic formation, more attention paid to the theoretical elaboration *vs.* the urgency of the rescue activity in the field, more visibility for specialists' work *vs.* the traditional isolation of the scientific world, the dangers of automation of data processing *vs.* the possibility of managing a wealth of information, the seeking for spectacular results *vs.* the critical processing of the data, the simplification in knowledge transferred to the public *vs*. a much deeper involvement of local communities—these are only some aspects of the crucial challenge that will hopefully see cultural landscapes at the centre of any future planning for a sustainable development.

GIS and the wider family of Information and Communications Technologies have also given more dynamism to the world of archaeologists, who can much more easily interact with each other and hence can more easily enter into scholarly debates and controversies. The large number of Web sites dedicated to fora for discussion of matters connected with GIS applications in the field (e.g., www.gisarch.com; www.esri.com/industries/archaeology/index.html), the availability of readily-accessible documents with suggestions for enhancement or expansion of the software and the real-time scientific debate on the Internet have given rise to a new "community of research" (Weatley & Gillings, 2006), where finally the Sciences of Antiquity are no longer confined to a marginal role.

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KEYWORDS

CAD (Computer Aided/Assisted Design/Drawing): Vector-based software that assembles data consisting in points, lines, volumes and instructions. Images (plans, maps, drawings, axonometric views, etc.) are built within a referencing coordinates system and data are usually displayed in layers. That permits rotation, inversion, panning, zooming and navigation thought the structures. As since the late 1980's CAD has developed three-dimension functionalities, the mark-line between Computer Design and other three-dimensional modeling programs has started to blur.

Cultural Resource Management (CRM): The entire set of operations involved in investigating, recording, handling and protecting the Cultural Heritage by a series of institutions, agencies, associations, administrators and individuals. CRM is nowadays intended in a wider meaning, as it includes not only artifacts and monumental structures but also all the traces that the past has left in and around the human habitat.

DEM/DTM: Digital elevation and digital terrain models of the earth surface, that take into account not only the topographic height of the terrain (normally expressed in meters above sea level) but also any variation over the land surface. Most of DEM and DTM are produced extracting and processing the contour and height information in topographical maps and aerial photography, but any measurable landform and any physical characteristic of a landscape can be elaborated in a DTM (e.g., pottery distributions or land-division elements).

GIS: A geographic information system or geographical information system (GIS) is, in the strictest sense, a computer-based technology for acquisition, storage, integration, manipulation and analysis of spatial data and associated attributes. In a more generic sense, GIS is not only a system that presents information about geographic space, but mostly a tool that allows users to create interactive queries (user created searches), analyze the spatial information, and edit data.

GPS: The global positioning system (GPS) is a worldwide radio-navigation system formed from a constellation of 24 orbiting satellites (US Department of Defense) and their ground stations. GPS receivers, nowadays sufficiently reliable, easily transportable and reasonably priced, exchange radio signals with the satellites that are orbiting above the area concerned, and estimate the coordinates position whose accuracy varies of the orders of meters or even centimeters.

Landscape Archaeology: Branch of archaeology that aims at the historical reconstruction of settlement dynamics and settlement patterns, resources exploitation modalities and ecological transformation in the course of time, and traces sequences of interactions between human occupation and environmental phenomena.

Spatial Data Analysis: A set of techniques, ranging from those of the statistics to those of locational modeling, that allows statistical tests of spatial data and analyzes their patterns of distribution.

Survey and Sampling: archaeological practice aiming at systematically recording archaeological sites and elements that are still perceptible on the terrain, under the form of still visible structural remains, earthworks or scattered artifacts. Survey is a fundamental investigative method of Landscape Archaeology, aiming to collect data about ancient settlement distribution and to locate unknown archaeological sites and features without recourse to excavation. Given the usual extension of the area to cover, only few sectors of it could be sampled or selected by means of random choice or a complex statistical analysis.

Higher Education's New Frontier for the E-University and Virtual Campus

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INTRODUCTION

Technologies entered in education since their first appearance and were used both for improving the efficacy and efficiency of traditional teaching and for creating new teaching-learning opportunities (Galliani et al., 1999). The definition "educational technologies" was coined in the 1950s to describe the equipments to be used in teaching-learning controlled environments. The introduction of the computer in teaching led to the definition of "new educational technologies" to mark the overcoming of traditional systems like audio-visual media (i.e., cinema, radio and television) with the new digital medium.

In the 1970s the Association for Educational Communications and Technology (AECT) formulated the definition of instructional technology as "… the theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning. ... We can think about it as a discipline devoted to techniques or ways to make learning more efficient based on theory but theory in its broadest sense, not just scientific theory".

The Internet in the 1990s introduced further elements of innovation in the use of technologies for education with an exponential growth of instruments and resources leading to the transition from face to face (f2f) teaching to online teaching-learning experiences.

The Internet more than other technological experiences entered in the educational systems all over the world and is today marking a revolution in continuous education and lifelong learning.

Universities, like many other institutions, have been fully invested from the innovation in teaching-learning processes and often participated in the transformation of distance education in on line education. Among the best examples on this regard are the Open University and the Phoenix University online, where people can earn they degrees fully online.

After delay, Traditional universities are concerned today with the use of technologies for the improvement of the efficiency of their courses, the monitoring of students' careers and the access to continuous education opportunities.

In what follows a survey of the Italian situation as an example of the more general European context will be analyzed and the research funded from European Commission will be reported.

ITALIAN UNIVERSITIES AND E-LEARNING

European universities have met the challenge of modernisation by introducing e-learning activities in their organization. The governments also encouraged the establishment of e-learning in higher education by supporting the digitization of the infrastructures of their institutions.

The ELUE project (E-Learning and University Education) belongs to the initiatives approved and funded from the European Commission for the promotion of e-learning and aims at the diffusion of e-learning in the university in Finland, France and Italy. The study reports the results of a joint survey carried out on the universities of the respective countries by the Conference of Italian University Rectors (CRUI), by the *Conference des Presidents d'Université Française* (CPU) and by the Finnish Virtual University (FVU).

The project belongs to the set of initiatives designed to foster the creation of an European Area of Higher Education (as referred to from the European Community action in the Bologna Process) and its main ideas and aims can be summarized as follows:

- The systematic analysis of e-learning experiences and their sharing could help in the achievement of a progressive convergence of the university

Table 1. Participation of the Italian university system in the survey

	Universities	%
Universities which filled in the questionnaire	59	76.6
Universities which didn't fill in the questionnaire	18	23.4
Total	77	100.0

systems in the individual countries towards the establishment of a unique European model,

- The collection and the dissemination of statistical information on the state and role of e-learning in the universities of the countries involved in the project are the main information to be shared. The project also aimed at the individuation of elements useful in identifying, understanding and implementing an observatory on e-learning evolution in the universities.

The results of the investigation were published in 2006 and are available online on the Website of the CRUI (2006).

In what follows some data on the participation in the survey of the Italian universities is reported and the information considered relevant for what follows is discussed.

In Table 1 the percentage in the distribution of Italian universities in the survey is shown.

When limiting to the universities participating in the survey (59 on 77) it emerged that only 64% among them (i.e., 49% of total number of universities) stated that they had an e-learning policy. Figure 1 depicts the percentage of universities reporting the presence of an e-learning policy.

It has to be noted that assuming 51% of the universities without an e-learning policy is realistic because the lack of an answer to the survey is widely synonym of a lack of policy on e-learning.

Furthermore the presence of ICT centres has been investigated and 84% of the universities answering to the survey declared the existence of at least one structure of this kind (i.e. 64,37% of the Italian universities). In Figure 2 is reported the graphic of the distribution. This datum has to be completed with the number of ICT centers in the Italian universities as reported in Table 2.

Figure 1. Percentage of the universities reporting the presence of an e-learning policy

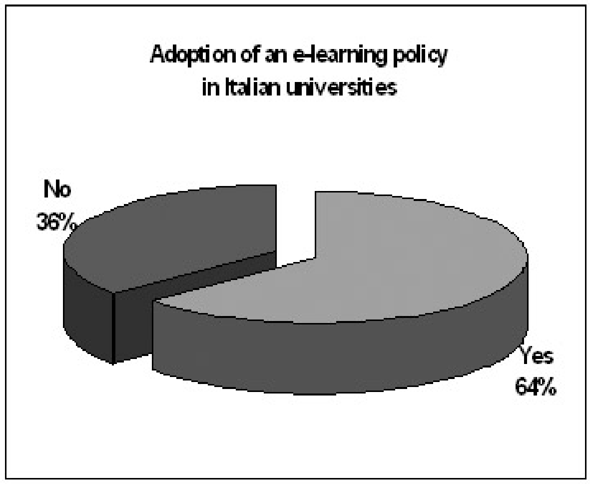


Table 2. Distribution of e-learning centres in Italian universities

Number of e-learning centers	Absolute value	%
One	26	33.77
Two	14	18.18
More than three	19	24.68

The only remark on the data in Table 2 is the lack of completeness of the same data, because it cannot be automatically deduced that universities which did not answer to the survey did not have one or more e-learning centre (they could have them in the faculties or in other structures).

At last when asked to indicate if research activity was made on e-learning and ICT use in the university only 49% among them declared they had this activity in their agenda (i.e., 37,55% of the universities).

Figure 3 reports how universities make or plan to make research on e-learning and ICT use in education in the Italian universities which answered to the survey.

It is clear from the data reported until now how complex is the context of the e-learning presence in Italian traditional universities where e-learning is present in single structures and is object of study and research but is not an integral part of the university management strategies in teaching.

Figure 2. Percentage of the universities reporting the presence of an ICT center

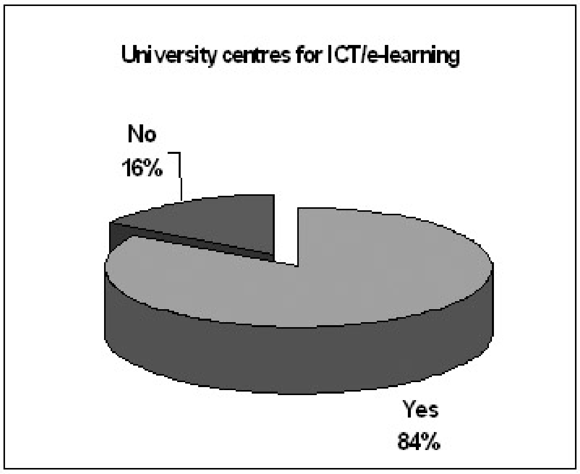
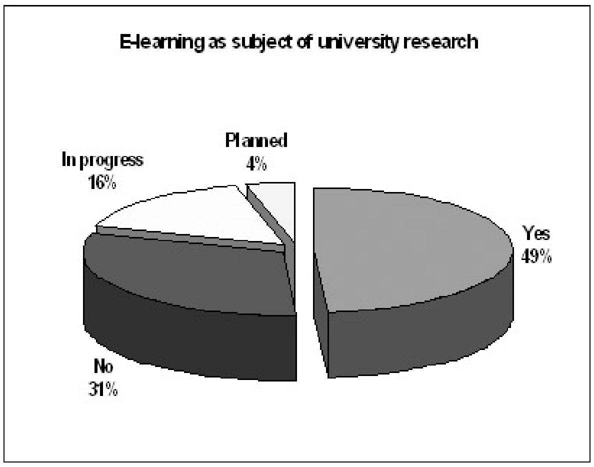


Figure 3. Percentage of the university research on e-learning



It is beyond the scope of this chapter a detailed discussion of the results of the ELUE project but to have a more complete panorama of Italian situation some further information is needed.

In Italy a special law, the so called Moratti-Stanca Law (from the names of two Minister of the former government who proposed it), recently introduced (2003) Telematics Universities and stated:

a. The rules and duties those universities are subjected to,
b. The creation of a Committee all Telematics Universities are submitted to for the approval and the accreditation,
c. Whatever distance education strategy the University uses for its courses it has to guarantee and verify the presence of the students at the ending examinations (both in single courses and final theses).

Until now eight Italian institutions have been accredited as telematics universities and the National Council for University (CUN, 2005) recently published a document stating what follows:

- The Law suggests the introduction of e-learning strategies at different levels in traditional universities together with the creation of new structures (telematics universities), but except a few requests only accreditation for new telematics universities have been asked for,
- Telematics universities do not make research adequately neither in e-learning and distance learning strategies and application nor in the scientific fields of the courses they propose,
- There is great anxiety for the use of distance learning and e-learning in medical professions (both in initial and in-service training),
- The introduction of e-learning in traditional courses is affected from the problem of the e-tutor presence/absence, which has not been adequately solved.

E-LEARNING IN EUROPEAN UNIVERSITIES AND THE EUROPEAN COMMISSION INITIATIVES

The previous paragraph shows how complex the Italian situation is as regards e-learning and its use in the universities. In other European countries the situation is similar to the Italian one also if the numbers are different from country to country. To give impulse to the e-learning policies in the universities of the corresponding countries the European Commission promoted many workshops and conferences and supported with grants many e-learning projects. Actually the main aspects the European Commission is working on are concerned with:

- The cooperation among high education institutions on the planning of joined curricula involving different universities, including the agreements

for evaluation, validation and recognition of the acquired competences (on a national basis),
- Large scale experiences on virtual mobility together with the physical mobility,
- The development of innovative study curricula based both on traditional learning methods and on line methods.

To the whole set of the above aspects in the context of the e-learning program the European Commission gave the name of *European Virtual Campuses* (notwithstanding the absence of a well settled definition of virtual campus).

In what follows the reports from the European Commission on virtual campuses will be analyzed in a great detail due to the relevance they have on the e-learning development plan.

In the consultation workshop held in Brussels on 23rd November 2004 (EC, 2005a) three definitions emphasising different aspects of a virtual campus were proposed:

- *Collaborative perspective*, denoting ICT-based collaboration of different partners supporting both learning and research in a distributed setting,
- *Enterprise (economic) perspective*, denoting an ICT-based distributed learning and research enterprise.
- *Networked organization perspective*, denoting an environment which augments and/or integrates learning and research services offered by different partners.

At the workshop held in Brussels on 11th October 2005 (EC, 2005b) to explore the issues associated with Virtual Campuses (VCs), one of the four key themes of the EU's *e*Learning Programme, the need for a critical review of existing projects in this area was identified. The workshop identified a range of issues that affected the successful implementation and deployment of VCs and their long-term sustainability.

Among the conclusions of the European commission is that if e-learning and VC initiatives are to be sustainable within the EU, then it is vital that stakeholders understand how new models of teaching and learning transform the institution and how they can be used to enhance the flexibility and inclusiveness of the European education system.

The starting point for the revision work has been the set of the projects funded from the Education, Audiovisual & Culture Executive Agency (EACEA). The list of the projects as they were approved and funded in three different years is reported in Table 3.

It has to be noted that in the 2006 call for proposals within the eLearning Programme, the EACEA stated that two priorities had been retained for the call:

1. Systematic critical review of existing virtual campus projects or experiences, including their valorisation in terms of sharing and transfer of know-how, with an eye to supporting deployment strategies at a European level,
2. Support for the dissemination or replicable solutions to help set up virtual campuses at European level and to establish a community of decision-makers.

The above list does not exhaust the e-learning initiatives in Europe and, what's more, do not include the many e-learning experiences all over the world. It is beyond the aims of this work the detailed analysis of all the e-learning experiences and of the great deal of virtual campuses projects, but the following examples can help in better understanding the e-learning impact on education:

- Virtual campuses involving universities in regions which had no or less contacts for a long time have been planned and carried out (like the Baltic Sea Virtual Campus where universities from Poland, Estonia, Latvia, Russia, Finland, and so forth cooperate in the development of master programs)
- Virtual campuses based on the use of virtual reality environments are available on the Net (the Nanyang University in Singapore is one of the most interesting examples on this regard),
- International scientific institutions like ESA (European Space Agency) and NASA (USA Space Agency) created virtual campuses for employers' training and for cooperation among scientists all over the world.

Table 3. List of EACEA virtual campuses projects in 2004, 2005 and 2006

2004 virtual campuses projects
REVE – Real Virtual Erasmus
eLene-TT e-Learning Network for Teacher Training
ELLEU E-learning per le Lingue e le Letterature Europee
E.A.S.Y Agency for EaSY Access to Virtual Campus
E-LERU Creation of LERU (League of European Research Universities) virtual campus
eTTCampus European Teachers and Trainers Campus
VICTOROIUS VIrtual Curricula ThrOugh Reliable InterOperating University Systems
MASSIVE Modelling Advice and Support Services to Integrate Virtual Component in Higher Education
VIPA Virtual Campus for Virtual Space Design Provided for European Architects
Virtual COPERNICUS-CAMPUS
2005 virtual campuses projects
eduGI Reuse and Sharing of e-Learning Courses in GI Science Education
eLene-EE Creating Models for Efficient Use of Learning – Introducing Economics of eLearning
E-MOVE An Operational Conception of Virtual Mobility
E-Urbs European Master in Comparative Urban Studies
EVENE Erasmus Virtual Economics & Management Studies Exchange
EVICAB European Virtual Campus for Biomedical Engineering
PLATO ICT Platform for Online learning and Experiences Accreditation in the Mobility Programme
VENUS Virtual and E-Mobility for Networking Universities in Society
2006 virtual campuses projects
VCSE: Virtual Campus for a Sustainable Europe
eLene-TLC eLearning Network for the development of a Teaching and Learning Service Centre
PBP-VC Promoting best practices in virtual campuses

CONCLUSION AND FUTURE TRENDS

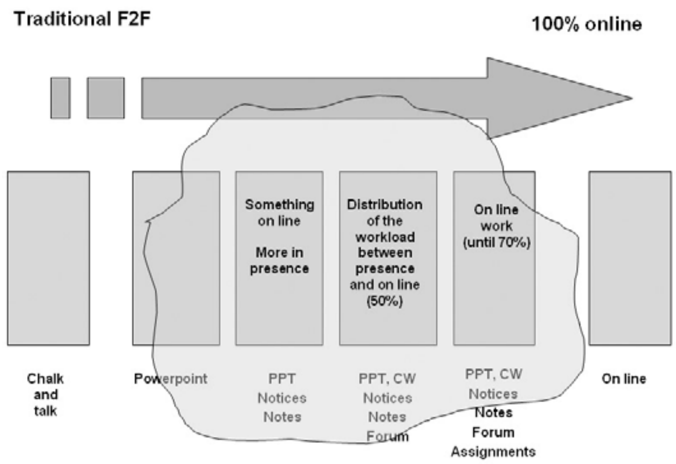
The experiences reported in the former paragraphs give a snapshot of the changes induced from ICT in High Education and confirm (whenever the need for a demonstration was required) that:

- Times and spaces of high education are rapidly changing,
- Deep organizational changes are needed to face the requirements for high quality continuous education,
- Digital literacy is a need for actual and future generations.

Until now it can only be deduced that a lot of experiences, involving at different levels e-learning instruments and strategies, are available and they are

H

Figure 4. Synthesis of the different e-learning experiences in today universities



well summarized in the image from P.C. Rivoltella (2004) in figure 4.

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KEY TERMS

Blended Learning: The combination of at least two different approaches to learning. It can be accomplished through the use of virtual and physical resources, i.e., a combination of technology-based materials and face-to-face sessions used together to deliver instruction.

Bologna Process: European reform process aiming at the creation of an High Education European Space within 2010. Actually it includes 45 countries and many international organizations. It pursuit the organization of the national High Education Institutions so that: (a) curricula and degrees are transparent and readable, (b) students can make their studies wherever they want in Europe, (c) European High Education can attract extra-European students and (d) an high quality knowledge base for the social and economic development of Europe is made available.

Brick and Click University: A definition of university which is derived from a business model (bricks-and-clicks). In that model both offline (*bricks*) and online (*clicks*) activities and presences are integrated.

Instructional Technology: A growing field of study based on the use of technology as a means to solve educational challenges, both in the classroom and in distance learning environments. Resistance from faculty and administrators to this technology is usually due to the fear in the reduction of human presence in education it is hypothesized to induce.

Lisbon Conference: Held in January 2000 (in Lisbon) and underlined the aim of making the European Union the most competitive and dynamic society of the world, based on innovation and knowledge.

Virtual Learning Environment (VLE): A software system designed to help teachers in the management of educational courses. The system can often track and monitor the students' operations and progress. It is often used to supplement face-to-face classroom activities.

Virtual University: Sometimes called *telematics university* is an organization that provides higher education on the Internet. Among these organizations there are truly "virtual" institutions, existing only as aggregations of universities, institutes or departments providing courses over the Internet and organizations with a legal framework, yet named virtual because they appear only on the Internet.

I

ICT and Interculture Opportunities Offered by the Web

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BACKGROUND

In Italy, as in other European countries such as Germany and France, the words "multicultural" and "intercultural" have distinct meanings[1]. In some ways the passage the one from the other indicates the evolution of a concept that, when examined in detail, forces us to re-examine educational political, and cultural choices in a society.

"In Italy, especially in the field of pedagogy, the term multicultural indicates a situation where cultures co-exist side by side but as yet, have not found a means of comparison and relating to each other . <…>. The term *intercultural*, which originated in France and then spread to other European countries, on another hand, describes a situation of interaction between different cultures, often describing a prospect, a possible point of arrival or an objective to strive for; a situation in which the people of different cultures begin to open up to reciprocal relationships, thereby bringing about the possibility of integration, characterised by a political and cultural pluralism which aims at reciprocal respect and appreciation between the respective cultures"[2]. With Multiculturalism, people accept to live with those from other cultures with tolerance but without promoting forms of exchange and democratic co-existence. The form of social organization that derives from this is that of the "melting pot" which encourages the development of ghettos or "Little Italy" and "China towns". However the Intercultural approach is reciprocal. It is for those who accept and listen, those who are tolerant, those who are not afraid of "contamination" but constantly seek to mediate between different points of view and backgrounds.

Among various other factors, it is globalization, encouraged by new communication and information technologies, that has contributed to the transformation of contemporary world-wide society into a multicultural society. These technologies have made it possible to communicate easily and at low cost with every corner of the planet. We can observe events which are taking place all over the world and take part in collective cultural processes. The Internet is made up of interconnected nodes without a centre. It encourages the growth of new trans-national communities on various levels, ranging from the political and professional to the scientific. It produced some elements of standardization, such as the use of a single language, English and has lead to uncommon social contacts on a worldwide level. At the same time however, these new communication technologies can also be viewed as a further cause of the divide between those who can access information and participate in the creation of knowledge and those who cannot.

FOCUS

The concept of freedom of access to information is an integral part of the philosophy and history of the Internet. It is also guaranteed by the characteristics of computer mediated communication and tools such as e-mail, forums, mailing lists, blogs and portals. CMC has changed the concept of communication itself. Leaving behind the one-way logic of communicator-receiver (typical of traditional mass media) the situation has become one where individuals are nodes in a network, part of an interconnected environment. The individual has the active role of social participant in communication rather than being a passive consumer (as in the case of television).

In addition to this, there are a number of new opportunities available for the user. It is now possible to influence the information circuit significantly. People can provide information as well as obtain it, they can teach as well as learn and participate not only as an individual, but as part of a group. From the moment a person becomes aware of this new communicative reality and has the possibility of taking part in it, he or she possesses new rights and also responsibilities. The rights include the opportunity to access the Web and its contents independently of limits (economic, time, and movement) and diversity (cultural, social, cognitive, or physical). To this we can add the right to learning. This must take into consideration, not only the acquisition of technical and procedural knowledge but also cognitive, emotive and social competences which are needed in order to participate with full awareness in a form of communication which is also building knowledge. There also the ever present problem of standardized positions, so the individual must be aware of personal expectations and needs, and adopt a critical, constructive attitude and be able to question, make hypotheses, choices and checks. Moreover, it is necessary to do this in a social setting which requires emotional control and an ability to collaborate, mediate and negotiate.

The communicative environment is that of the Web where the passage between the exchange of information and the building of knowledge is potentially fast, thanks to the network that allows for an exchange rather than a one-way flow of information. This environment is one of democratic co-existence based on mutual respect. It appreciates individuality and cultural and social diversity. At the same time the right to access is also accompanied by certain responsibilities towards others. Anyone who takes part in this communicative process becomes an adherent of the philosophy of Internet. As a direct consequence of its genesis and evolution, it appears to be more closely associated with the technology of freedom rather than that of control, and with democratic relationships rather than ideological imperialism.

There are various types of free information on the web today. They can be placed into two categories: new forms of news agencies and new forms of publishing. Both fit into to the intercultural and democratic view which requires free information, originating "from below" that is, from all the links in the network, combined with fast transmission speeds and a high level of diffusion. Examples of the first category are blogs and more organised agencies such as Misna, an international press agency run by congregational missionaries in Africa, Asia, Latin America and Oceania. Though possessing few resources it can boast many successes and has earned "recognition after only a brief period of activity including the award of the 'St Vincent 2002' journalism prize"[3].

The archives of scientific literature (papers, journal articles, addresses made at conferences) are another important example of freely available information on the Net. Offered in an electronic format at no cost, by the very universities that finance the research and believe in the principle of free access to information, they are potentially useful to everyone from college students in America to the doctor in a hospital in Tanzania

Thus we can state the Internet's contribution to interculturalism has manifested itself in three ways: the creation of a cyber-culture; in a new concept of knowledge; and in the participation "from below" in the building of learning:

Internet as a place of communicative interaction and universal culture.

For Lévy, what is interesting about cyber-culture is the coming together of all differences and heterogeneity. He believes in the ability of cyberspace to bring out the best of human intelligence in every person through communicative relationships which create a collective intelligence and a cyber-culture. In this sense we can assert that cyber-culture is both a transculture and an inteculture, since it is universal without being oppressively uniform.

If we take cyberspace to be the *location*, then communication is the *means* that permits the creation of this collective intelligence and cyber-culture. Computer users can communicate with each other in a novel way on the Internet since they can be more than mere passive users and isolated consumers like today's television viewers. Communication is not limited to "one to one" exchange. In cyber culture it is reciprocal, interactive and communitarian. Moreover it is universal as anyone can be an active communicator. The expansion of interconnections displays the fact that there is one general humanity. This is what Levy means by "universal": the idea of universality in the Enlightenment sense of the word, where our goal is the unity of human kind and the affirmation of universal principles such as the rights of Man. All human beings can come into reciprocal contact virtually and become conscious collectively of their existence. The more we add links, the more diverse and heterogenic material is circulated on the net. Humanity is becoming aware of itself (universality) but this awareness has no one meaning. It does not pass through one central point and is not bound by any set of laws unlike science where, for example, universal gravitation is the same everywhere. What is interesting in cyber-culture is the bringing together of all differences and heterogeneity

Internet as a location for new knowledge which is open, complex, multidisciplined, individual, and collective at the same time.

Morin (2000) has highlighted the problem of the inadequacy of knowledge (which is *divided* by the boundaries between disciplines while the reality of the world is increasingly global and interconnected) and the challenge of complexity. Complexity is a method and a form of knowledge which requires a dialogical approach. Gregory Bateson also spent his life demonstrating the interdependence between elements and the interconnections between different worlds and disciplines. He theorises about the ecology of ideas, an ecosystem in which there is a plurality of levels of application of ideas, using a systematic approach which, from the point of view of learning means giving importance to contexts, relationships and functions.

So the new idea of knowledge, does not only refer to concepts that are to be *transmitted* but, above all, to the itineraries and the network of individual and collective experiences which are in a state of perpetual change.

This is the challenge that the individual can take up, not withstanding the risks of cognitive standardisation on one hand, and fragmentation or individualism on the other. Morin's "tête bien faite" requires the full use of intelligence in the organisation of ideas, in the search for links, routes and new itineraries, knowing full well that it is not possible to attain totality but that we must put into *practice* collective and individual cognitive *practices* at the same time because they exploit the power of connectivity. "If a document is put on the World Wide Web you are doing two things at the same time: firstly, you are increasing the amount of information that is available, but secondly, you are doing another thing with the links between your document and the others: you offer the surfer who finds your document your point of view. So you are not merely offering information but a point of view in a collection of information. The World Wide Web is not only an enormous mass of information, it is the expression of thousands of different points of view. It should be viewed from this aspect" (Levy, 1995). There is space for every diversity and every point of view on the Web which doesn't have to become individualism, if you allow yourself to become enchanted by hyper-textual logic, by the links and maps and if you allow yourself to feel part of a whole, a collective intelligence and a universal culture.

Internet as a place for forming an opinion, expressing a critical judgement, and participating in the building of knowledge.

A surprising example of the impact of the Internet on the power of the individual and thus of the group, is the increase in public access to health information. This is not just another step in the spread of knowledge, but a political change which introduces a new balance of power. More and more patients arrive at their doctor's with information they have found on the Web. It may be incomplete or taken from dubious sites, but they begin their treatment in a more knowledgeable and participative way. Even though there are limits and the information is certainly not enough to provide specialist knowledge, it is enough to modify the power/knowledge rapport in the doctor/patient relationship.

The potential for forming opinions, and thereby expressing judgements and making demands aided by the Web, is becoming more apparent in the political development of citizens. People can participate in public debates as they once did in the classical agora. They can inform themselves and take up positions through blogs, messaging systems and online journalism.

If we say that technology is not neutral and the choice of technology produces profound effects, the most evident effect of the Internet is the transition from vertical to horizontal communication. The first has an undeniably authoritarian nature, even if the intentions of those using it are democratic, since it requires a silent, passive viewing. The second however, permits active participation, and while this alone is not enough to confer unquestionably democratic credentials, it certainly transforms the quality of communication. In general, the passage from one-way communication to interactivity does not automatically guarantee a growth in democracy. On the contrary it can increase the use of extorted consensus to legitimise solutions taken without the effective participation of citizens.

The key question is thus the following: Can the Internet be used to manipulate consensus? Is there a social use of new technologies? Up to now citizens have been subjected exclusively to vertical information offered by television, which creates passivity in viewer. The condition of citizens using the web, benefiting from horizontal communication which blurs the distinction between producers and consumers and the supremacy of the former over the later, is totally different. Everyone becomes a supplier of information, and as such, an active player in communication. The most marginalized of Internet users can have word power equal to that of a government, especially when the news they wish to communicate is information that others want to suppress at any cost. Censorship becomes much more difficult, but with one condition: that there is a real mass internet information literacy program and a true universal service. Without this there is the risk that an information apartheid emerges. Moreover, there is also the danger of *hyper-information,* where citizens are unable to pick out the important information and check its validity due the potentially unlimited quantity of information available. It is for this reason too that the role of education in permitting a social use of new technologies is increasing. It has an important part to play in training active, knowledgeable citizens, to guarentee an adequate command of the tools necessary for developing the competences required by society.

According to Rifkin, cultural production is the first level where the economic life of a country is played out. In consequence of this, there is a strong move to control such production in the direction of a standardised predetermined models (Rifkin, 2000).

But if it is true that the Internet is disliked by governments because it cannot be censored or controlled easily, it can also become a tool in the democratic education of citizens, if the move towards liberty prevails over that towards standardisation. A conscious citizen is a person who participates in the building of a free, universal society which is constantly developing and changing. The process of building knowledge that can come about through the use of the network of ideas and information available on the Internet produces social progress. This is what Dewey calls "social efficiency": everything that makes an experience valid for the community, as well as oneself; everything that makes it communicable and useful in the demolition of social barriers. The same efficiency that he considers to be the final aim of education in a democratic society.

CURRENT LIMITS AND FUTURE DEVELOPMENTS

Technology of Freedom or Technology of Control?

Whether we consider technology to be neutral, or something that can structure the user's activities, we cannot avoid reflecting on the responsibilities of those who use it and the need for user-education. Whilst there is a great potential for helping humanity, we face a number of new questions. A critical analysis can reveal both positive and negative aspects, opportunities and risks, and a possible direction to take in order to achieve a democratic use for the civic education of the citizen. The key question is that posed by Stefano Rodotà: Are we using the technology of freedom or the technology of control? Can the use of technology be free from rules? Is it necessary to reflect on which direction we should be striving for?

We need to free ourselves from some vices of form and clichés that linger, such as technological arrogance (and the idea that technology does not need rules), the optimism of the market (which in reality favours economic interests over social equality) and the political-ideological simplification which sees technology as a cure for all evils (in reality technology is not neutral but requires careful use)

The Digital Divide

Regarding access to the new communication technologies and the internet in particular, there are no equal opportunities between the technologically advanced rich countries and countries which are technologically behind. In a message of 2002, the secretary general of the United Nations Kofi Annan underlined the importance of communication technologies and exhorted poor countries on the African continent to unite to create a digital revolution which had become indispensable. In collaboration with the ITU International telecommunications union the UN organised the first World Summit on the Information Society, WSIS with the aim of building a common vision of the information society and adopt a plan of action to bring it about[4].

The first principle of the Geneva declaration states:

We, the representatives of the peoples of the world, assembled in Geneva from 10-12 December 2003 for the first phase of the World Summit on the Information Society, declare our common desire and commitment to build a people-centred, inclusive and development-oriented Information Society, where everyone can create, access, utilize and share information and knowledge, enabling individuals, communities and peoples to achieve their full potential in promoting their sustain-

able development and improving their quality of life, premised on the purposes and principles of the Charter of the United Nations and respecting fully and upholding the Universal Declaration of Human Rights.

It is not enough to be connected to resolve the fundamental problems of underdevelopment and to ensure that the Information Society becomes a vehicle for democracy, justice, equality and respect for individuals and their personal and social development. Beyond the mere physical availability of a computer, other factors such as economic/social resources and levels of literacy, influence the successful use technology. It is the development of the necessary competences and a fruitful, informed use of the internet that is the challenge for the current Information Society and lifelong learning in particular.

CONCLUSION

In conclusion Internet is a wonderful opportunity (comparable with the impact on culture of the invention of the printing press) not only when we consider the technical changes in the exchange of information and the spread of knowledge, but also for the political, social and educational implications. In substance we have to start to conceive and use new democratic environments for the production of culture, new forms of diffusion which offer efficient tools for communication between individuals, disciplines and political and social points of view. To use a more traditional pedagogical language, what emerges from the analysis of the spontaneous (and in some cases experimental) use of the internet is the necessity to use the great potential for communicative and didactic renewal which is beginning to manifest itself, in order to produce a culture that overcomes individualism and is oriented towards forms of collaboration which widen the opportunities for democratic participation in the information/knowledge process. By moving in this direction perhaps we can cement the relationships between individuals, groups, states, and political organisations providing a glimpse of the added value of cooperation, reciprocity, peace ,and thus interculture.

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WEB SITES

Misna, www.misna.org

Misna, (Missionary International Service News Agency) provides daily news from for and about the South of the World.

Open Archives Iniziative, http://www.openarchives.org

The Open Archives Initiative develops and promotes interoperability standards that aim to facilitate the efficient dissemination of content. The Open Archives Initiative has its roots in an effort to enhance access to e-print archives as a means of increasing the availability of scholarly communication. Continued support of this work remains a cornerstone of the Open Archives program. The fundamental technological framework and standards that are developing to support this work are, however, independent of the both the type of content offered and the economic mechanisms surrounding that content, and promise to have much broader relevance in opening up access to a range of digital materials. As a result, the Open Archives Initiative is currently an organization and an effort explicitly in transition, and is committed to exploring and enabling this new and broader range of applications. As we gain greater knowledge of the scope of applicability of the underlying technology and standards being developed, and begin to understand the structure and culture of the various adopter communities, we expect that we will have to make continued evolutionary changes to both the mission and organization of the Open Archives Initiative.

Public Library of Science, http://www.plos.org/

PLoS, a nonprofit organization of scientists and physicians committed to making the world's scientific and medical literature a freely available public resource. As of 2006 it publishes *PLoS Biology*, *PLoS Medicine*, *PLoS Computational Biology*, *PLoS Genetics* and *PLoS Pathogens*. PLoS ONE is a new journal to be launched soon.

Our goals are (1) to open the doors to the world's library of scientific knowledge by giving any scientist, physician, patient, or student—anywhere in the world—unlimited access to the latest scientific research. (2) Facilitate research, informed medical practice, and education by making it possible to freely search the full text of every published article to locate specific ideas, methods experimental results, and observations. (3) Enable scientists, librarians, publishers, and entrepreneurs to develop innovative ways to explore and use the world's treasury of scientific ideas and discoveries.

PubMed Central (PMC), http://www.pubmedcentral.nih.gov/

PubMed is a free search engine offering access to the MEDLINE database of citations and abstracts of biomedical research articles. It is offered by the United States National Library of Medicine as part of the Entrez information retrieval system. MEDLINE covers over 4,800 journals published in the United States and more than 70 other countries primarily from 1966 to the present.

Ricerche di Pedagogia e Didattica, http://rpd.cib.unibo.it

Freely accessible journal of the university of Bologna on pedagogical and didactic topics

Unione Europea, http://europa.eu/index_it.htm
Portal: "Recommendations of the European Parliament and Council regarding key competences for lifelong learning", 11/20/2005.

KEY TERMS

Cyberculture: For Lévy, what is interesting about cyberculture is the coming together all differences and heterogeneity. He believes in the ability of cyberspace to bring out the best of human intelligence in every person through communicative relationships which create a collective intelligence and a cyberculture. In this sense we can assert that cyberculture is both a trans-culture and an interculture, since it is universal without being oppressively uniform.

Democratic Education: Morin has highlighted the problem of the inadequacy of knowledge (which is *divided* by the boundaries between disciplines while the reality of the world is increasingly global and interconnected) and the challenge of complexity. Complexity is a method and a form of knowledge which requires a dialogical approach. Gregory Bateson also spent his life demonstrating the interdependence between elements and the interconnections between different worlds and disciplines. So the new idea of knowledge, does not only refer to concepts that are to be *transmitted* but, above all, to the itineraries and the network of individual and collective experiences which are in a state of perpetual change. The process of building knowledge that can come about through the use of the network of ideas and information available on the internet produces social progress. This is what Dewey calls "social efficiency": everything that makes an experience valid for the community, as well as oneself; everything that makes it communicable and useful in the demolition of social barriers. The same efficiency that he considers to be the final aim of education in a democratic society.

Democratic Information: The concept of freedom of access to information is an integral part of the philosophy and history of the internet. It is also guaranteed by the characteristics of computer mediated communication and tools such as e-mail, forums, mailing lists, blogs and portals. CMC has changed the concept of communication itself. Leaving behind the one-way logic of communicator-receiver (typical of traditional mass media) the situation has become one where individuals are nodes in a network, part of an interconnected environment. The individual has the active role of social participant in communication rather than being a passive consumer (as in the case of television).

Information Society: It is now possible to influence the information circuit significantly. People can provide information as well as obtain it, they can teach as well as learn and participate not only as an individual but as part of a group. From the moment a person becomes aware of this new communicative reality and has the possibility of taking part in it, he or she possesses new rights and also responsibilities. The rights include the opportunity to access the web and its contents independently of limits (economic, time, and movement) and diversity (cultural, social, cognitive or physical). To this we can add the right to learning. This must take into consideration, not only the acquisition of technical and procedural knowledge but also cognitive, emotive and social competences which are needed in order to participate with full awareness in a form of communication which is also building knowledge.

Intercultural Education: In Italy, as in other European countries such as Germany and France, the words multicultural and intercultural have distinct meanings. In Italy, especially in the field of pedagogy, the term multicultural indicates a situation where cultures coexist side by side but as yet, have not found a means of comparison and relating to each other. The term *intercultural*, which originated in France and then spread to other European countries, on the other hand, describes a situation of interaction between different cultures, often describing a prospect, a possible point of arrival or an objective to strive for; a situation in which the people of different cultures begin to open up to reciprocal relationships, thereby bringing about the possibility of integration, characterised by a political and cultural pluralism which aims at reciprocal respect and appreciation between the respective cultures.

ENDNOTES

1 In North American and the majority of English speaking culture however the term *multicultural* is most widely used (especially in education).

This can be observed when consulting ERIC, the bibliography data base of the U.S. Department of Education which specializes in topics relating to pedagogy and didactics and representative of North American scientific literature. In its thesaurus *intercultural education* is only considered as a synonym for *multicultural education*. The only exception is *intercultural communication*.

2 Genovese A. (2003). *Per una pedagogia interculturale. Dalla stereotipia dei pregiudizi all'impegno dell'incontro,* Bologna, BUP, p. 181.

3 http://www.emi.it. Description of the agency MISNA, under the heading of "cards, profiles," where they are actually exposed the various associations that work with MISNA.

4 http://www.itu.int/wsis/

ICT and the Virtual Organisation

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INTRODUCTION

The need to be adapted to the changes in the environment, to improve the operational efficiency, and to increase the level of satisfaction in customers has promoted the redesigning of the firm's organisational processes. Firms tend each time to externalise activities at a different level by making the appearance of new models of organisation possible. The analysis of different theories coming from a variety of literature reviews offers us the opportunity to affirm that being virtual is a characteristic present today in firms at different levels (Shin, 2004). In this article, we offer a definition for the concept of virtual systems. An explanation from the strategic management field is also accompanied. Finally, this analysis attempts to draw an explanatory model of the capacity of value creation in the virtual systems in comparison with traditional alternatives.

BACKGROUND

The redesign of productive systems in the firm around the concept of being virtual finds a theoretical point of view in different thoughts coming from the strategic field. The evolution of the theory of the transaction costs recognises the barriers in accumulating core competencies (Prahalad & Hamel, 1990), especially in the conditions firms are living in today with a high technological uncertainty (David & Han, 2004; Walker & Weber, 1984). Maybe for this reason firms should develop a different way of acquiring knowledge from third parties.

The resource dependency theory (Aldrich & Pfeffer, 1976) also supports the need to complement, in this context of complexity and dynamism, different internal and external competencies. The fact that a variety of organisations are sharing their intangible assets promotes the need of developing a common language, a context of trust and mutual compromise and an infrastructure of communication for an effective exploitation. All this recognises the benefits derived from the partial codification of a certain group of expressions of tacit knowledge since it improves the processes of identification, transfer, retention, and exploitation of strategic routines and processes (Faucheaux, 1997; Khalil & Wang, 2002).

The agency theory (Fama & Jensen, 1983; Jensen & Meckling, 1976) also offers an argument for the appearance of virtual systems in some conditions. The high interdependence amongst a group of agents involved in the satisfaction of the same specific opportunity in the market can explain a decrease in the partners conflicts and in the agency costs. This way, the production structures can be converted into an effective alternative to create and sustain competitive advantages.

The evolution of the resource based view (Peteraf, 1993) in the dynamic capacities focus (Teece et al., 1997) and the theory of knowledge (Nonaka & Takeuchi, 1995) widens the analysis of uncertainty in decision making. In these situations, the cooperation with other stakeholders in order to complement the firm's specific base of knowledge can be the best alternative to create value.

VIRTUAL SYSTEMS

There is not a uniquely recognised definition for virtual systems (De Pablos, 2006). Some authors consider virtual systems as intermediate mechanisms that operate between markets and hierarchies for organising the economic activity (Davidow & Malone, 1992). This perspective describes a virtual system as a group of interlinked networks sharing a specific problem (Greiner & Metes, 1995; Lipnack & Stamps, 1997; Preiss, Goldman, & Nagel, 1996).

Many of these analyses recognise that the virtual systems imply the integration of different value chains, where any of the agents is specialised in a phase of the process and offers its core competencies to the rest of the partners. This way, a group of competitive advantages and upper gains can be obtained. Besides, these systems offer great difficulty in identifying the participants and their real value to the final product or service. This can be a key success factor to sustain competitive advantages through time (Goldman, Nagel, & Preiss, 1995; Nikolenko & Kleiner, 1996).

Virtual System Definition

Davidow and Malone (1992) cite for the first time the term "virtual" as an expression of a very agile and flexible organisation that is quite customer centred. Later on, Travica (1997) proposes a definition of virtual organisation as a temporal or permanent collection of individuals geographically dispersed, groups, or organisational units that depend on electronic linkages to complement a process of production. From our perspective, the virtual system appears as an alternative way of designing the structure of an organisation containing the basic characteristics of high levels of cooperation amongst the different agents implied in the system of value creation in the company, a high use of information and communication technologies and high levels of flexibility and time response to contingencies in the market. This is the reason why we propose a definition of virtual organisation as:

An organisational structure that, including components of one or various firms they are shaped around a group of core competencies by promoting the inter-firm co-operation by an adequate use of information and communication technologies and with the main objective of the achievement of business processes oriented to the creation of value for all and any of the partners. (De Pablos, 2006)

Virtual Systems Elements

Now we describe the main elements of the virtual system as we have already stated.

1. *Cooperation*

Byrd and Marshall (1997) define cooperation as any type of official or unofficial agreement achieved by two or more firms with the main objective of implementing a certain degree of collaboration amongst them. The outsourcing appears as one of the most common mechanisms used when searching it. In the process of getting virtual, there is a need to establish any kind of mechanism to coordinate the different disintegrated activities. The virtual system uses as a main mechanism of coordination the cooperation amongst different activities. As the firm transfers some of its activities to the value system, some elements for the integration of processes can be of crucial importance, as it is the case of information and communication technologies.

2. *Information and Communication Technologies*

A key element in the virtual system is the capacity of acquiring and integrating a massive flow of information and being able to exploit it cleverly. For that reason, the success in a virtual system is going to depend on the ability to develop with efficiency the process of managing the information. Information and communication technologies used in the last years as main assets in the corporate strategy play an important role in the process of virtualisation in the organisations in two aspects (Rayport & Sviokla, 1995):

- They allow the breaking of activities in the value chain by maintaining the firm's differential competence in their coordination.
- A transfer of activities from the tangible to the virtual value chain is produced.

This way, the technological context makes the virtual model easier. The ICTs allow the development of a typical virtual organisational environment. They permit the maintenance of innovative applications that allow a decrease in costs, improvement of the internal coordination, and better customer service. Some authors such as Travica (1997) established types of virtual systems by using, as almost exclusive criteria, the use of information and communication technologies.

3. *Flexibility: A Main Element in the Virtual Organisation*

Firms search for organisational efficiency by promoting the flexibility of the labour relationships in the work methods and in the employed technology (Brian, Doorley, & Paquette, 1990) since they offer a better response to changes in the environment. The virtualisation of processes produces a better efficiency to the firm, and it allows, at the same time, multiplying the capacity of their structures through the use of adapted market networks. The virtual organisation makes closer the work processes to the customers and offers more agile and diverse alternative ways of operating. Table

Table 1. Original approaches to virtual systems (© 2007, Carlos de Pablos. Used with permission)

Author	Focus	Co-operation agents	Main objectives	Space	ICT role
Davidow and Malone (1992)	External	Independent firms	Value chains interlinked by a central agent		Integration of knowledge
Byrne (1993); Byrne et al. (1993)	External	Independent firms	Value chains interlinked without a central agent		Integration of knowledge
Goldman et al. (1995)	External	Independent firms	Common objectives		Integration of knowledge
Preiss et al. (1996)	Internal	Organisational units in a same firm	Integrate complementary knowledge		Integration of knowledge
Travica (1997)	Mix	Individuals, work groups and independent firms		Geographic dispersion	Integration of knowledge
Schertler (1998)	External	Small independent firms	Interlinked value chains		Integration of knowledge
DeSanctis and Monge (1999)		Organisational entities		Geographic dispersion	Integration of knowledge
Hedberg et al. (2001)	External	Independent firms	Value chains interrelated by a central agent	Geographic dispersion	Integration of knowledge
Saabeel et al. (2002)	External	Independent firms	Interrelated value chains	Geographic dispersion	
Fernández Monroy (2003)	External	Independent firms	Interlinked value chains	Geographic dispersion	Integration of knowledge
De Pablos (2006)	Mix	Individuals, Work groups and Independent firms	Main objectives		Integration of production and knowledge

1 offers a summary of some original approaches to the concept of virtual systems.

THE CREATION OF VALUE THROUGH VIRTUAL SYSTEMS

From a strategic point of view, the creation of value is related with the achievement and sustaining of competitive advantages. That it is the reason why in this work the influence of virtual systems over these elements of the value creation is analysed. Any of the agents taking part in the virtual system offers to the value chain specialised knowledge. This way any agent is centred in those aspects from the productive processes that constitute their core competencies (Prahalad & Hamel, 1990). The competitive advantages derived from this definition are mainly based in two main aspects:

- The flexibility in the market response (Byrd & Marshall, 1997)
- The main levels of organisational efficiency that can be translated into less costs of production (Goldman et al., 1995).

Table 2. Effects of the different dimensions of a virtual system on the creation of value (© 2007, Carmen de Pablos. Used with permission)

Virtual systems dimensions	Creation of value	
	Competitive advantages	
	Creation	Sustainability
An increase on the cooperation agreements with other interested partners	More specialisation (core competencies)	More difficulty in identifying and evaluating the approaches coming from the participants More difficulty to imitate and substitute the relevant business processes by external agents operating outside the virtual system
The intensive use of information and communication technologies	A rapid transfer of relevant knowledge More efficiency in the transfer of relevant knowledge	
Flexibility	Fastness in the access to the resources Efficiency in the access to the needed resources	

The high levels of dynamism and technology intensity in the environments in which the virtual production systems operate are especially interesting and justify at a great level the benefits deriving from a high specialisation in the participants of the network.

The benefits arising from virtual organisations are stressed by an increase in the use of ICT, especially on networks that group quite dispersed agents. That is the reason why the geographic proximity is no longer a main element for the final success in the cooperation agreements. Information and communication technologies allow a fast and efficient transmission and exploitation of the codified knowledge that is useful for different members in the network (Crossan & Berdrow, 2003; De Pablos, 2006). Thus, higher levels of virtual systems derived of an increase in the number of cooperation agreements in the participant agents, a decrease in their relative size, and an intensive use of information and communication technologies will produce better competitive positions. Table 2 summarises the main effects of each of the dimensions of a virtual system on the creation of value.

CONCLUSION

Virtual systems are working as an alternative organizational mechanism to provide some businesses economic activity. First, we try to find a scientific explanation for the existence of this kind of system in the theories coming from the strategic management field. From the agency theory up to the evolution of the resourced based view, there are many different theories where the value systems can be scientifically explained. After that, we try to find a proper definition for a virtual system in the context we analyse it. Some elements such as the need for firm's cooperation, the massive use of information and communication technologies, and the advantages of being more flexible are, from our view, key elements in the concept for virtual systems. Last, we show a basic model trying to group the different theoretical debates around virtual systems and the creation of value. We promote the approach of the influence of the virtual systems on the creation and sustainability of a competitive advantage. The design of models for managing knowledge can be a very interesting trend when trying to find a proper explanation to the development, storing, transfer, and exploitation of shared intangible assets.

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KEY TERMS

Business Process Redesign: A systematic way of improvement that drastically evaluates, rethinks, and implements the change of processes of an organization. The main goal of this orientation is to achieve dramatic improvements in performance in processes.

Core Competencies: The principal distinctive capabilities possessed by a company.

Dynamic Capabilities: Organizational actions that use resources to integrate and reconfigure actions in order to match and create changes in the market.

Information and Communication Technology (ICT): A wide term that includes any communication device or application, for example, Internet, radio, television, cellular phones, computer and network hardware and software, satellite systems, and so on, as well as the various software services and applications associated with them, for example, the ERP systems, data warehouses, and so forth.

Intangible Assets: Those resources that cannot be seen, touched, or physically measured in a firm and which are created through time and/or effort.

Tacit Knowledge: It is knowledge that people carry in their minds and is therefore difficult to access. The transfer of tacit knowledge is difficult and generally requires extensive personal contact and trust.

Virtual System Management: It is the process of managing the allocation and use of remote located resources capabilities.

ICT Investment Evaluation Practices in Large Organizations

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INTRODUCTION

Business-to-business electronic commerce (B2BEC) represents the largest growth sector, that is, 80% of revenues—in e-commerce (Pires & Aisbett, 2003). IDC predicts that Australian B2BEC spending will grow at 70% annually and is likely to reach $166.25 billion by 2006 (Pearce, 2002). ICT investments in B2BEC are used to assist in the interorganization acquisition of goods into the value chain and to provide interfaces between customers, vendors, suppliers, and sellers (Barua, Konana, & Whinston, 2004). Although B2BEC provides organizations a wealth of new opportunities and ways of doing business, it is extremely difficult to evaluate and therefore, have yet to prove enduring sources of profit (Laudon & Laudon, 2004).

Research studies and practitioner surveys report contradictory findings on the effect of the ICT expenditures on organizational productivity (Thatcher & Pingry, 2004). In particular, measurement of the business value of ICT investment has been the subject of considerable debate among academics and practitioners (Brynjolfsson & Hitt, 2003; Sugumaran & Arogyaswamy, 2004). Although some ICT productivity studies have produced inconclusive and negative results (Zhu, 2004), other research indicated that spending in ICT is directly related to organizational performance (e.g., Hu & Quan, 2005). Some researchers (e.g., Brynjolfsson & Hitt, 2003; Zhu, 2004) suggested that the confusion over ICT productivity is due to, among other things, the lack or inappropriate use of ICT evaluation and benefits realization methodologies or processes.

Given the complexity of the decisions and the large expenditure involved, determining the impact of ICT investment evaluation and benefits realization has been and will continue to be an important research concern for both researchers and senior managers. Therefore, better understanding of the basis and practice of ICT investment evaluation in large Australian organizations is warranted. The objectives of this chapter are to undertake a study that attempts to: (1) investigate the current practices in managing ICT benefits and evaluation by large Australian organizations; and (2) determine the relationships between the levels of B2BEC support, B2BEC effectiveness, B2BEC resources, and the use of ICT investment evaluation and benefits realization methodologies or processes in large Australian organizations.

BACKGROUND

There appears to be no consistent evaluation and measurement of ICT investment by most organizations (Kim & Umanath, 2005; Lin, Lin, & Tsao, 2005a). Since the evaluation of these ICT investments is a complex tangle of financial, organizational, social, procedural and technical threads, many of which are currently either avoided or dealt with ineffectively (Torkzadeh & Dhillon, 2002). However, according to the 2003 SIM survey, measuring the value of ICT investment remains as one of the top five concerns for senior managers (Luftman & McLean, 2004).

Despite the fact that evaluation of ICT infrastructure in electronic commerce initiatives such as B2BEC has been shown to be critical to successful implementation, the major benefits organizations can gain from ICT investments are inherently qualitative and cannot be easily assessed beforehand and calculated in monetary terms (Lewis & Byrd, 2003). The problem becomes more evident as ICT is used to link the supply chain or to change the structure of industries, and costs and benefits have to be tracked across functional and organizational boundaries (McKay & Marshall, 2004).

This is because that the nature of electronic commerce technology makes it harder for organizations to allocate and assign costs and benefits to ICT projects, further blurring the lines of capital investment and return from ICT spending in the B2B channel (Kleist, 2003; Subramani, 2004; Tsao, Lin, & Lin, 2004). The less precisely bounded environment of B2B electronic commerce technology adds more complexity to the ICT measurement problem as this type of investment is physically distributed between suppliers and customers (Torkzadeh & Dhillon, 2002).

Moreover, many organizations have found that these ICT project costs and benefits can be difficult to estimate and control (Lin & Pervan, 2003; Love, Irani, Standing, Lin, & Burn, 2005). For instance, many organizations face a challenge of measuring and monitoring the performance of the specific contribution of inputs in generating outputs as well as its associated Internet channels (Kim & Umanath, 2005; Lin, Pervan, & McDermid, 2005b). Other less quantifiable items such as loyalty, trust, knowledge, relationships, value creation and customer satisfaction all makes the evaluation even more difficult (Straub, Rai, & Klein, 2004). Efforts to identify the relationships between the evaluation practices and the organizational constraints and benefits and to develop measures for B2B electronic commerce initiatives have been hindered by the lack of necessary conceptual bases (Torkzadeh & Dhillon, 2002).

For example, investigation by Sohal and Ng (1998) found that in large Australian organizations the potential of ICT has not been utilized to meet the competitive challenges due to inadequate and inappropriate appraisals/evaluation of the proposed ICT investment projects. Moreover, they reported that 45% of the responding organizations did not evaluate whether ICT systems were still consistent with business objectives and 59% did not determine whether expected benefits were being achieved. Some of the major problems associated with ICT investment evaluation are: (1) there is a lack of understanding of the impact of the proper ICT investments evaluation and benefits realization processes in most of the organizations (Ward & Daniel, 2006; Willcocks & Lester, 1997); (2) traditional financially oriented evaluation methods (e.g., ROI, NPV) can be problematic in measuring ICT investments and quantifying relevant benefits and costs (Bardhan, Bagchi, & Sougstad, 2004); (3) organizations often have neglected to devote appropriate evaluation time and effort to ICT as well as to deal with the extended investment time frame (Stamoulis, Kanellis, & Martakos, 2002); (4) working with new technology introduces higher levels of risk, which affects timing, costs and delivery deadlines (Peacock & Tanniru, 2005); and (5) it is very difficult to evaluate intangibles and make relationship between ICT and profitability explicit (Murphy & Simon, 2002).

Furthermore, ICT investment evaluations alone are insufficient in terms of ensuring that the benefits identified and expected by organizations are realized and delivered (Ward & Daniel, 2006). This is because ICT is just one enabler of process change (Grover, Teng, Segar, & Fiedler, 1998) and it only enables or creates a capability to derive benefits. The essence of benefits realization process is to organize and manage so that the potential benefits arising from the use of ICT can actually be realized (Ward & Elvin, 1999). Benefits may be considered as the effect of the changes, the difference between the current and proposed way that work is done. Indeed, good management of organizational change is important to ensure successful ICT investment evaluation and benefits realization processes (Dhillon, 2005). Finally, effective use of ICT benefits realization processes also allows organizations to constantly focus on the planned ICT benefits and by making sure that ICT investments remain aligned with business goals as well as to make strategic adjustments in resources in a changing environment.

RESEARCH HYPOTHESES AND METHODOLOGIES

As mentioned earlier, the current practices of the Australian organizations to manage and evaluate their ICT investments and their ability to realize the benefits from these investments in an increasingly competitive market are of interests to the researchers and senior executives. Therefore, there is a pressing need for undertaking a survey research to investigate the relationship between the B2BEC and the use of ICT investment evaluation and benefits realization methodologies or processes. The following four hypotheses are proposed:

H1: Organizations with higher levels of usage of ICT investment evaluation methodologies will lead to higher levels of usage of ICT benefits realization processes.

H2: Organizations with higher levels of B2BEC benefits will lead to higher levels of usage of ICT investment evaluation methodologies.

H3: Organizations with higher levels of B2BEC resources will lead to higher levels of usage of ICT investment evaluation methodologies.

H4: Organizations with higher levels of B2BEC readiness will lead to higher levels of usage of ICT investment evaluation methodologies.

Questionnaires were sent to ICT managers/CIOs of 900 Australian organizations randomly selected from top 2000 Australian organizations (Dun and Bradstreet mailing list) in 2005. The survey was conducted to investigate many aspects of ICT investments evaluation and benefits realization practices in large Australian organizations. In total, 176 responses were received, representing a response rate of 19.6%. In addition, late returns were compared with other response received earlier in order to check for nonresponse bias (Armstrong & Overton, 1977). No significant differences were detected between two samples.

Respondents were asked to indicate their agreement on a 5-point scale (1 for strongly disagree and 5 for strongly agree) with statements concerning five main constructs: (1) B2BEC benefits; (2) B2BEC resources; (3) B2BEC readiness; (4) ICT investment evaluation methodology; and (5) ICT benefits realization process. The reliability analysis was conducted on these constructs (see Table 1).

Measurement items used in the *B2BEC effectiveness, B2BEC resources, and B2BEC support* scales were partly derived from scales used by Chan and Swatman (2000) and Eid, Trueman, and Ahmed (2002), and the rest were created by the researcher. These scales measured the organizations' levels of B2BEC benefits, resources, and readiness.

Table 1. Scale reliabilities for the five main constructs

Constructs	Scale reliability
B2BEC benefits	0.83
B2BEC resources	0.72
B2BEC readiness	0.69
ICT investment evaluation methodology	0.84
ICT benefits realization process	0.85

The *ICT investment evaluation methodology and benefits realization process* scales were derived from Ward, Taylor, & Bond (1996). These scales measured the organizations' usage, wide use and effective use of ICT investment evaluation methodology and ICT benefits realization process.

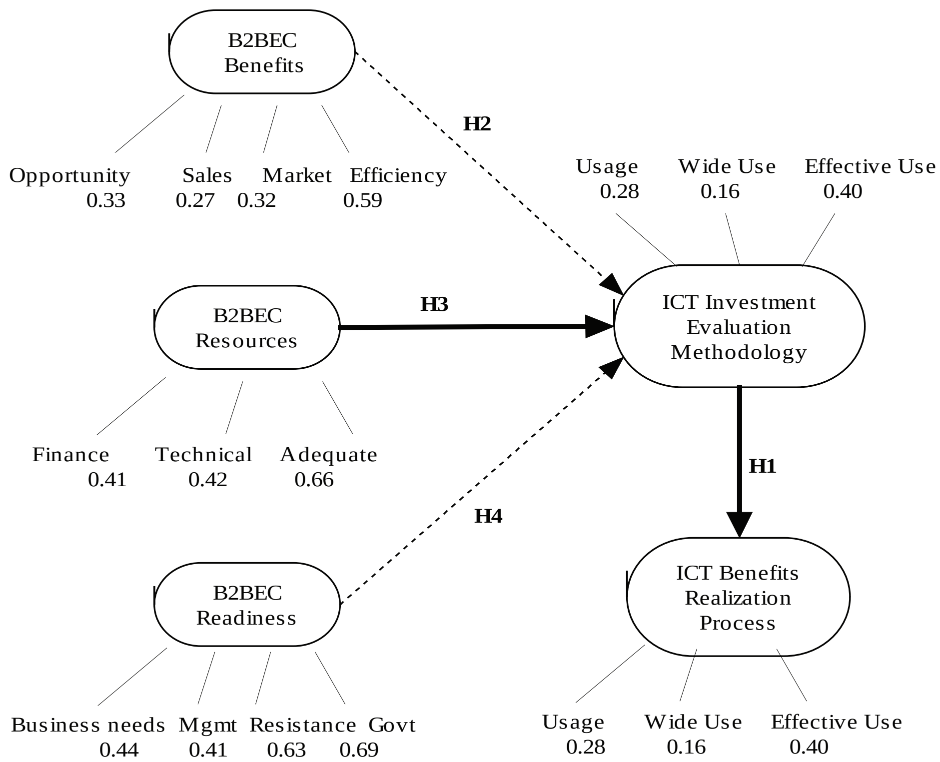
DATA ANALYSIS AND RESULTS

In the following discussion of results the percentages referred to normally represent the proportion of valid (answered) cases only and did not indicate missing values. SPSS (v11) and LISREL VIII (Jöreskog & Sörbom, 1993) were used to analyze the data collected.

The results indicated a reasonably high adoption of methodologies for ICT investment evaluation (63.1%) and processes for ICT benefits realization (40.4%). In addition, respondents indicated that ICT investment evaluation methodologies were widely used (selected 4 or 5 out of a five-point scale ranging from "totally disagree" to "totally agree") in only 50.5% of cases. However, this percentage is a lot higher than the surveys conducted in large Taiwanese organizations (22.6%) (Lin, Pervan, Lin, Tsao, 2004) and in large UK organizations (36%) (Ward et al., 1996). Moreover, respondents indicated that ICT benefits realization processes were widely used in only 28.1% of cases. This result is mostly consistent with findings of two SMEs Australian studies by Jensen (2003) and Marshall and McKay (2002) where the ICT benefits realization processes were not widely used by virtually all respondents.

LISREL VIII was then used to analyse the model shown in Figure 1. Each construct in the model was analysed separately and the fit of indicators to the construct as well as construct validity were evaluated to achieve a acceptable fit. The model achieved an acceptable level of fit: $\chi^2(222) = 485.86$, p=0.000, RMSEA=0.083, GFI=0.804, and AGFI=0.756. The analysis revealed that B2BEC benefits and B2BEC readiness did not have a significant and positive impact on the use of ICT investment evaluation methodology ($\beta = 0.06$, t = 0.77 and $\beta = -0.08$, t = 78, respectively). Therefore, **H2** and **H4** were rejected. However, the analysis indicated that the path from B2BEC resources to ICT investment evaluation methodology was positive

Figure 1. Structural equation model results



Note: All coefficients are standardized.
All solid line path coefficients are significant at $p < 0.05$. (The dotted line coefficient is non-significant.)

and significant ($\beta = 0.30$, $t = 3.29$), suggesting that the provision of more B2BEC resources to the responding organizations had led to higher usage of ICT investment evaluation methodology. Furthermore, there was also a positive relationship between ICT investment evaluation methodology and ICT benefits realization process ($\beta = 0.81$, $t = 7.85$), indicating that the evaluation of B2BEC would lead to a higher level of ICT benefits realization activities by the responding organizations. Thus, **H1** and **H3** were supported.

DISCUSSION AND CONCLUSION

The results showed relatively high usage of ICT investment evaluation and benefits realization methodologies or processes by large Australian organizations. However, these methodologies were generally not used widely and effectively within the responding organizations. Most ICT evaluations were carried out to ensure that the expected benefits/objectives were met and the quality of their ICT investments improved. In addition, the structure equation modeling (SEM) analysis revealed that there was a direct positive relationship between the use of ICT investment evaluation methodologies and benefits realization processes or activities.

Moreover, most respondents were not satisfied with their use of B2BEC. The results demonstrated that there was a significant positive relationship between the use of ICT investment evaluation methodologies and the B2BEC resources held by the respondents. However, it was also found that the level of B2BEC effectiveness and supports did not have a significant relationship with the use of ICT investment evaluation methodologies.

Finally, this study took place at a particular point in time. Further research can be conducted to determine whether or not there are relationships between other factors related to the adoption of B2BEC (e.g., degree of satisfaction), the usage of ICT investment evaluation methodologies, and benefits realization processes or activities.

FUTURE TRENDS

More recent evidence suggests that many organizations simply got carried away with ICT and spent money unwisely in the last few decades. The future trend is that more successful organizations will analyze and evaluate their economics carefully and continue to explore new ICT applications in order to gain competitive advantage. These organizations will spend on only those ICT applications that would deliver productivity gains and evaluate their ICT investments carefully through a disciplined approach with innovative management practices.

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KEYWORDS

B2BEC: Business-to-business electronic commerce. Business conducted through the Internet between companies.

Benefits Realization: It is a managed and controlled process of making sure that desired business changes and benefits have been clearly defined, are measurable, and ultimately to ensure that the changes and benefits are actually realized and delivered.

Electronic Commerce: The paperless exchange of business information using the Web and related technologies in business**.**

ICT Benefits Realization Processes: Approaches that are used to ensure that benefits expected in the ICT investments by organizations are achieved.

ICT Investment Evaluation Methodologies: Approaches that are used to evaluate organizations' ICT investments.

ICT Productivity Paradox: Despite large investments in ICT over many years, there have been conflicting studies as to whether or not the ICT benefits have actually occurred.

Investment Evaluation: This is the weighing up process to rationally assess the value of any acquisition of software or hardware which is expected to improve business value of an organization's information communication systems.

ICT Literacy in the Information Age

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INTRODUCTION

It is necessary to begin this thesis by briefly defining and discussing the ideas of the "*information age*" and "*ICT literacy*".

The Information Age

The development of homosapien man can be classified into *ages*. These ages fundamentally affect the patterns of how humans work, play and interact. Some social anthropologists (e.g., Toffler & Toffler, 1994) have identified three such ages: agricultural, industrial, and information. Definitions of these ages are complex, and a detailed discussion of them lies outside the scope of this chapter, however, they can usefully be typified as follows:

- The *agricultural age* affected us through *systems* geared to processing and distributing *food*.
- The *industrial age* affected us through systems geared to processing and distributing *energy*; energy that is harnessed to provide large-scale travel and automation.
- The *information age* affects us through systems for processing and distributing *information*.

Therefore, in the Information Age many people will work and play exclusively using ICT systems and use this technology as a primary means of interacting with other people.

According to Castells (1996) we are presently in a transitory period, which he terms "*industrial-informational*" whereby we are integrating the new (ICT) technology of the information age into systems that were conceived in the industrial age. It is this integration that gave rise to for example, computer integrated manufacturing (CIM), "fly by wire" aircraft, and "smart bombs". However, present patterns of human behaviour remain generally similar to that of the industrial age and these will only shift significantly as we complete the transition into the information age. Such transitory periods are challenging for us because, in order to maintain social inclusion, we must fundamentally change our skills and mind sets to be compatible with the systems of the new age.

ICT Literacy

A useful starting point is to consider the European Computer Driving Licence (ECDL, 2004) initiative. This originated in Finland and has become somewhat of an icon for the idea of ICT literacy. This framework has a clearly defined scope and the learning is fairly prescriptive. It emphasises the attainment of specific knowledge points associated with *(pre)specified* tasks and goals.

Reid (1992) appropriately contextualizes the ECDL's perspective of ICT literacy within the wider idea of ICT literacy when writing:

An old definition of "computer literacy" is the ability to write computer programs. But this is not very relevant today, in the era of packaged application software.

One common view of IT literacy is to say that "computer literate" people are those who can use a few standard (or widely used) application packages (such as a word-processor and a spreadsheet), know how to manage their data, and know how to find out more if they need to. But this is a very mechanical definition, in which we are judging a person's literacy by what they commonly do, rather than by the special abilities they may possess.

The use of the term "computer literacy", or "IT literacy", begs a comparison with conventional, or "reading" literacy. Here we are not so much concerned with whether a person does much reading, but whether they can, when the need arises—and they are sufficiently familiar with the advantages of reading, *that they can make sensible decisions about whether to read something or not.*

The most useful definition then is that an IT literate person is one who knows when to use which IT for what purpose, and knows where and how to find out more about areas where their competence is inadequate. Thus they may not, in fact, be regular users of IT, but they have sufficient perception about the various ITs that exist to be able to make sensible decisions about whether to use IT in a given situation or not.

Here, Reid demonstrates how the definition of ICT literacy depends upon the commentator's perspective and the time when the commentary is made. Reid also argues that the idea of ICT literacy is (necessarily) becoming much more one of a *general transferable skill*. In other words, ICT literacy should be seen as an ability that has application across disparate contexts and (technological) devices.

In keeping with this perspective, this article explains new thinking as to how we might (re)define and better engender ICT literacy for the needs of the Information Age.

BACKGROUND TO ICT LITERACY IN THE INFORMATION AGE

The industrial age reflects a period in which the economically driven goals were, in general, fairly prescribed, predicable and persistent. This meant that job roles had a considerable life span. In turn, this gave rise to the idea of *training* individuals for lifelong job roles. In contrast, the information age reflects a period in which the goals will be a far more dynamic, ephemeral, and unpredictable.

This aspect of the information age means that it will become increasingly difficult to predict what we will need to learn in advance. Existing knowledge will become redundant with increasing frequency (Lucas & Greany, 2000). Therefore, it is easy to conclude that, if individuals are to achieve social inclusion in this new age, it will require them to engage in lifelong learning. Further, learners will increasingly need to identify and realise their own learning requirements, and this will often need to take place in a *contingent* manner (Thimbleby, 1999). Therefore, the generic ability to learn is becoming more important than the subject matter, or content of what is learned. This is an idea termed *learnacy* by Claxton (1999).

Based on these discussions, initiatives such as the ECDL would seem to fit better with the needs of the industrial age than with those of the information age. As such, this author argues that new(er) initiatives to engender ICT literacy must begin with the rationale that ICT literacy is more of a general transferable skill, whereby individuals are equipped with the ability to learn new ICT efficiently and autonomously, and in a contingent manner.

Researchers within the SEUSISS (2003) project seem to support this idea. They found that only a small minority of employers regarded the ECDL as useful recruitment criteria, instead, they preferred the more *generic* ICT skills.

A NEW APPROACH TO ICT LITERACY: THE ADAPTIVE ICT LEARNER

The adaptive ICT learner model was designed by Macefield (2005) to engender ICT skills for the information age. In keeping with the comparison Reed (1991) made between ICT literacy and general literacy, it began with the idea that an ICT system interface can be modeled within the same framework we use to model a *natural language*.

Table 1. Grammar for a natural language

Semantics	The meaning of syntax, how it should be interpreted.
Syntax	A set of structural rules for how lexical items should be arranged including the use of functional constructs that glue the lexicon together.
Lexicon	A set (usually a hierarchy) of symbols that map to concepts (i.e., they have intrinsic meaning).

Table 2. Written English and MS Windows within the natural language grammar (Derived from Macefield, 2005)

	Written English	MS Windows GUI
Semantics	What phrases and sentences mean (e.g., how the sentence "the cat sat on the mat" relates to our experience).	What tasks can be performed using particular combinations of objects and operations (e.g., dropping a "document" onto a printer will result in printing a hard copy).
Syntax	The grammatical rules for English (e.g., a verb must refer to at least one noun).	The structure of valid operations that describe how objects can collaborate within the object model (e.g., toolbars can be "docked" into a window, but a toolbar cannot be dropped onto a printer).
Lexicon	Words of the lexical category (e.g., that the word "cat" refers to an object in the physical world)	The objects within the "object model" for the windows GUI (e.g., there in an object of type "icon" that has meaning).

Interfaces Modelled as Pseudo Natural Languages

All natural languages can be modeled within a metaframework known as the *natural language grammar*. This is shown in Table 1 with the lowest, or most fundamental, level at the bottom (therefore, the table is best read from bottom to top).

An ICT system interface can be mapped into this grammar. An example of this is shown in Table 2, which uses the examples of written English and the Microsoft Windows graphical user interface (GUI).

Here, the Microsoft Windows GUI has effectively been modelled in terms of a *pseudo natural language (PNL)*. In other words, the GUI is perceived as a communication device that is modelled within the natural language grammar.

Although, this modeling approach is novel, it does have some research history. Moran (1981) demonstrated how such an approach was beneficial although; however, his work was concerned more with text based command line interpreters where the mapping of a natural language to an interface is far more "obvious" than with a GUI. Alty (1997) also advocates that multimedia interfaces can be modelled within the natural language grammar; however, Alty does not appear to offer us any examples of this mapping.

It is not suggested that this analogy between natural languages and ICT system interfaces is totally consistent; however, it is argued that there is sufficient overlap that this modeling may have benefits in terms of understanding ICT systems. If learners can acquire a usefully complete and accurate PNL model of a GUI then this might help them when learning and utilising any application software that uses that particular GUI.

In some ways, this is analogous to the idea of very "traditional" teaching whereby we assume, or develop a good standard of literacy skills then expect students to be able to learn a lot of subject matter in a largely self-organized manner.

In developing these literacy skills, learners are generally taught to read and write within, what the author terms, a *literacy acquisition framework* that has the natural language grammar at its core. This framework is shown in Table 3, where specific elements of literacy education are associated with, or targeted at, specific levels in this framework. Importantly, Table 4 shows how this literacy acquisition framework can also be applied to the learning of a modern GUI.

Of course, literacy education does not happen in a linear manner through this framework. In other words, a learner need not acquire the entire lexicon of a particular natural language before they learn how to put some of these elements together into a phrase or sentence, that is, use the syntax. Rather, the teaching and learning involves multiple and overlapping iterations through the levels of the framework.

Grounded in this theory, it was hypothesized that the literacy acquisition framework may be used as an ICT literacy teaching and learning device that leverages a learner's innate natural language capabilities. To test this hypothesis, a proof of concept study was conducted at a UK university.

Table 3. Literacy acquisition framework (derived from Macefield, 2005)

	Traditional Literacy	ICT Literacy
Creativity	Creative writing and thinking: communicate in new ways, fantasize using language.	Creative, self-directed learning and application ICT of systems using the GUI.
Semantics	Interpret (read) and define (write) words and sentences in a way that expresses meaning.	Understand what sorts of tasks can be performed using a particular combinations of objects (e.g., dropping a "document" onto a printer will result in printing a hard copy).
Syntax	Organise (write) words into phrases and sentences according to grammatical (syntactic) rules.	Understand how object have and are manipulated and which operations arte valid.
Lexicon	Organise the alphabet into words, and then map these to particular objects or concepts (sometime referred to as pedagrammar acquisition)	Identify objects and object hierarchies within the GUI's object model (e.g., windows, buttons and toolbars) and associate these with the functions they perform.
Sensory Motor	Form letters of the alphabet (using pens and pencils).	Develop input/output device skills (e.g., Mouse, VDU, and keyboard).

Proof of Concept Study of the Adaptive ICT Learner Model

The study utilised a foundation level undergraduate course designed to develop basic skills in Microsoft Word, PowerPoint and Excel, which from hereon will be referred to as "the applications". Ordinarily, these students would have followed a fairly prescriptive "training type" course similar to that associated with the ECDL, a whereby *standard* (Word) letters, (PowerPoint) presentations and (Excel) expenses spreadsheets would be the expected outcomes.

The course was 10 weeks long with a single three-hour session per week. The first session was dedicated to motivational issues; in particular, expressing the importance of ICT skills within the information age.

Sessions two through seven took place within the literacy acquisition framework described in Table 4. These sessions included some formative exercises and assessments related to the learner's abilities at each level of the framework; beginning first with the "sensory motor" level. Interestingly, the participants were generally surprised at how little they knew about keyboard and mouse manipulation of the Microsoft Windows 2000 GUI; as compared with what they "thought" they knew. For example, many participants had either no concept, or only a fuzzy concept, of what the right mouse button was for. Similarly, few participants were aware that mouse and keyboard inputs could be made concurrently to deliver more advanced selection functions.

Another important feature of sessions two through seven was that considerable time was spent developing skills in using the *online help* facilities. In terms of a comparison with literacy, it is difficult to draw analogies here; however, the ability to exploit online help facilities is clearly critical in developing the idea of an *adaptive* ICT learner.

In sessions eight through ten the participants undertook an exercise with concrete goals. Unlike traditional training approaches such as those found in the ECDL, the participants defined their *own* goals (sometimes with advice from the author, or one of his assistants). For example, one participant wanted to organise a pool tournament for the class, which involved the production of mail merged letters, posters, and devices for recording results and issuing certificates. Other than being very tangible to the participants, these exercises had two important characteristics. Firstly, none of the participants had previously achieved similar goals. Secondly, they were given no instruction as to how to go about the exercises; indeed, they were not even told what applications(s) they might use in pursuit of these goals. Further, participants were encouraged to ask for assistance only as a *last resort* and, in these cases, the author and his assistants deliberately *minimized* the help provided.

Three outcomes of this study were notable:

- The adaptive ICT learner model was clearly more attractive to some learners than others. The resistance or scepticism in some participants might well be explained by the fact that we inevitably carry with us a legacy of industrial age type learning (training). This might be expected since we have not yet completed the transition into the Information Age. Task and goal specific learning still has both relevance and resonance for many learners. Hence, their concerns about newer, different, models of learning are legitimate and we will have to work hard to overcome these barriers in many instances.
- Evidence that learners had acquired a mental PLN model of the windows GUI was negligible; however, this outcome was unsurprising since many studies have demonstrated the difficulty in eliciting an individual's mental model within a human computer interaction (HCI) context (e.g., Sasse, 1997).
- *All* of the participants (eventually) achieved their goals for the exercise set in weeks eight through ten. Further, many of the participant's solutions involved outcomes, strategies, and features that were unfamiliar to the author. This is despite the fact that he would be considered a "power user" of these applications and has run numerous advanced courses on these technologies.

SUMMARY AND CONCLUSION

The adaptive ICT learner model has two key, and related, attributes:

- It proposes that ICT literacy should be viewed as a general transferable skill. As such, it focuses exclusively on the GUI rather than any specific application software with the aim that learners acquire a usefully complete and accurate model of the GUI that aids them when learning and utilizing any associated application software.
- The teaching and learning is based around the literacy acquisition framework, with the idea being to leverage a learner's innate natural language capabilities in order to make the learning more efficient and effective.

The literacy acquisition framework can also be used as a taxonomy by which we can *define* the idea of ICT literacy. In keeping with this, it can also be used as an *assessment device*. For example, it is easy to imagine how individuals' mouse and keyboard manipulation skills for a particular GUI might be (objectively) assessed, as well as their ability to identify and use particular aspects of the lexicon, syntax, and semantics. We might also (more subjectively) assess how creative a learner has been in their application of ICT.

In summary, the adaptive ICT learner allows us to define, teach and assess ICT literacy in a similar way to how we define, teach and assess literacy. Further, although some learners may have legitimate concerns about this model, it is argued that this model is well suited for our transition into the Information Age.

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KEY TERMS

Age: A period of time that has unique and identifiable (systems of) technologies that fundamentally affect how humans work, play, and interact.

Agricultural Age: A period in which human work, play, and interaction patterns are fundamentally affected by systems geared to the processing and distributing *food*.

Industrial Age: A period in which human work, play, and interaction patterns are fundamentally affected by systems geared to processing and distributing *energy*; energy that is harnessed to provide large-scale travel and automation.

Information Age: A period in which human work, play, and interaction patterns are fundamentally affected by systems for processing and distributing information.

General Transferable Skill: A skill that has application across disparate contexts and devices.

Learnacy: A general transferable skill that enables individuals to learn (faster and better) (Claxton, 1999). See "Learning how to learn" (Sein, Bostrom, & Olfman, 1999).

Literacy Acquisition Framework: A framework in which reading and writing (literacy) skills are learner that has the natural language grammar at its core.

Natural Language Grammar: Generalized framework into which all natural languages can be mapped. Consists of lexicon, syntax, (rules) and semantics.

Pseudo Natural Language (PNL): A communication device (such as a graphical user interface) that is modelled within the natural language grammar (see Aitchison, 1999).

ICT Policies in Africa

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INTRODUCTION

During the last 20 years, information and communication technologies (ICTs) have greatly provided a wealth of new technological opportunities, with the rapid deployment of both the Internet and cellular telephony leading the way (Sarkar De, 2005). ICTs can serve as potent agents of change (Yamuah, 2005). These technologies have invaded every country that is willing to accept and adopt them. The most important differentiating factor currently is policy. Policy makes a great difference regarding how countries are able to take advantage of the technological opportunities available to them and exploit them for good. Countries with progressive policies are seeing these technologies spread quickly. However, countries that are yet to formulate and integrate ICT policy have been plagued by slow growth of technology and the consequent lessening of support for economic and social development (Sarkar De, 2005).

Most African countries economies rely mainly on agriculture and a few mineral resources. It is time for African governments to embrace the new trend and agent of change—ICT and develop policies that will enhance the use of ICT as an instrument of socioeconomic development. This important vision which is lacking in most African countries, could be the turning point from poverty and misery on the continent to better the levels of life and happiness (Yamua, 2005). This paper dwells on ICT policies in Africa. It gives the definition of policy and ICT policy, x-rays ICT policy formulation, objectives of African ICT policies, sectoral applications of the policies, ICT policy implementation and future trends of ICT policies in Africa.

BACKGROUND

Simply put, policy is a plan of action (Kumar, 1993). A policy is a public statement of intentions and behavior norms that is usually, but not always, formalized and made explicit by a sovereign government, institution, corporation or other organizational entity (Horton, 1997; cited by Olatokun, 2005). Such official statements set forth a goal, a vision, a direction, organizational values and norms or other kinds of guiding principle(s) that a group, enterprise or nation intends to follow and adhere to in the pursuit of its everyday endeavors (Olatokun, 2005).

Policies are intended to regulate the conduct of people in systems, but policies themselves are often conditioned by the sociocultural dynamics of the human systems for which they are intended (Olatokun, 2005). Polices are usually put in place by various governments. However, different stakeholders and in particular, the private sector make inputs into the policy process and affect its outcomes (APC, n.d.).

Information and communication technology (ICT) is any technology, which enables communication and the electronic capture, processing, and transmission of information (Parliament Office of Science and Technology, 2006). ICTs have become very important to contemporary societies. Whether one is talking on the phone, sending e-mail, going to the bank, using a library, listening to sports coverage on the radio, watching the news on television, working in an office or in the fields, and so forth, one is using ICTs. However these ICTS do not operate in isolations from one another (APC, n.d.).

ICT policy is an official statement which spells out the objectives, goals, principles, strategies, etc intended to guide and regulate the development, operation and application of information and communication technology. According to the APC (n.d.), ICT policy generally covers three main areas—telecommunications (especially telephone communications), broadcasting (radio and television), and the Internet; it may be national, regional (and or subregional) or international; each level may have its own decision-making bodies, sometimes making different and even contradictory policies.

Even when promulgated as distinct policy statement, ICT policies must take into account other policy areas, such as education policies, information policies, trade and investment policies, and cultural and linguistic policies. The mere establishment of written national ICT policy, however, has value in itself. It conveys, at a minimum, the message that the government is forward—looking and intends to pursue the utilization of ICT in society. Governments should aspire, of course, to more by putting the policy content into actual practice and becoming a role model in applying ICT in their administration and services (UNESCAP, 2007).

An ICT policy framework is recognized as an important step in order to create an enabling environment for the deployment of ICTs and their uses to social outcomes. The lack of an ICT policy has been attributed as a key factor behind the poor infrastructure and of ICTs in many developing countries in Africa. While many developing countries in Africa have moved ahead and formulated an ICT policy, very little progress has been recorded in policy implementation (Njuguna, 2006).

ICT policies and strategies are essential tools to define Africa's response to the challenges of globalization and to nurture the emergence of an African information society. This is especially important given the rapidly growing international focus on ICTs and development (United Nations Economic Commission for Africa, 2001).

AFRICAN AND ICT POLICY FORMATION

The Organization of African Unity (OAU) in 1996 adopted the African Information Society Initiative (AISI) as the guiding framework for ICT efforts in Africa (Mutume, n.d.). AISI was adopted in May 1996 at the United Nations Economic Commission for Africa (ECA) Conference of Ministers. It has, since then, provided the framework for ECA's programs on Harnessing Information for Development (Bounemia and Soltane, 2001). AISI was to provide the framework for the African information technology renaissance and to be African information society by the year 2010 (Ya'u, n.d.).

At the time ECA launched/adopted AISI in 1996, the main constraint to African information society developments was the lack of infrastructure to support communication and access to information within the countries. Since that time, all African capital cities and several secondary towns have received connectivity (United Nations Economic Commission for Africa, 2001). The key policy challenges for Africa now are (United Nations Economics Commission for Africa, 2001):

1. Extending access
2. Applying the technologies to solve development problems
3. Collaborating to build market size and exploit economics of scale
4. Articulating an Africa vision in international negotiation on information society issues

The policy process must:

1. Involve broad groups of stakeholders including representatives of user communities and civil society
2. Identify issues that can best be addressed beyond national borders
3. Recognize the need for a stronger African voice in global negotiation

AISI gives strong support to the development of national ICT policies and strategies through its National Information and Communication Infrastructure (NICI) plan, which helps nations link to national, regional, and global development goals—including the Millennium Development Goals (Sesan, 2004).

Through the active support and encouragement received from ASISI, several African countries have formulated ICT policies. For instances in 2000, 13 of the 54 African countries had ICT policies; however, the number increased to 16 in 2002. Essentially the number of countries without ICT polices was reduced from 21 to 16 within the same period (AISI, 2003, cited by Sesan, 2004).

Examples of some African countries with ICT policies are:

- Ghana – Ghana ICT4D National Policy: http://www.comminit.com/ict/policies/ictpolicies-2.html
- Ethiopia – Ethiopian Science and Technology, National ICT Policy: http://www.telecom.net.et/-estc/_policy/index.htm

- Malawi – The Malawi ICt Policy: www.malawi.gov.mw/finance/DISTMS/TheMalawaICTPolicy.pdf
- Nigeria – National Policy for Information Technology (IT): http://www.nitda.gov.ng/nigeriaitpolicy.pdf.

Objective of African ICT Policies

Though ICT policies of the different African countries may not be exactly the same in structure and contents, the following are some objectives their policy frameworks are out to achieve (Federal Republic of Nigeria, 2001;UNESCAP, 2007; Republic of Ghana, 2006, Sarkar De, 2005):

- Increasing the benefits from ICT.
- Ensuring that ICT resources are readily available to promote efficient national development.
- Creating the necessary enabling environment to facilitate the deployment, utilization and exploitation of ICTS within the economy and society.
- Assisting people and organizations to adapt to new circumstances and providing tools and models to respond rationally to challenges posed by ICT.
- Facilitating the development, expansion, rehabilitation and continuous modernization of the country's information and communication infrastructure.
- Encouraging local production and manufacture of ICT components in a competitive manner.
- Providing individuals and organizations with a minimum level of knowledge and the ability to keep it up to date.
- Supporting the concept of lifelong learning.
- Identifying areas of priority for ICT development.
- Promoting legislation and policies for the protection of online, business transaction, privacy, and security.
- Enhancing the quality of services and products.

Sectoral Application of African ICT Policies

An African national ICT policy normally specifies the areas of the country the policy will be applied to. The policy gives direction on the strategies for using ICTs to improve on each sector of the country. The sectoral applications of the Nigeria national ICT policy document for example, include (Federal Republic of Nigeria, 2001).

- Human resource development
- Infrastructure
- Research and development
- Health
- Agriculture
- Urban and rural development
- Fiscal measures
- Government and private sector partnerships.
- Arts, culture and tourism
- National security and law enforcement
- Legislation
- Global consideration
- IT popularization and awareness

The Ghanaian ICT for Development policy document (Republic of Ghana, 2006) highlights how the ICT4D policy objectives can be achieved in the areas of:

- Agriculture
- Education
- Health sectors

By specifying the sectoral applications of the policy document, it will be possible to implement the policy statement to the advantage of the different sectors of the country.

IMPLEMENTATION OF ICT POLICIES

Adam (n.d.) notes that the up take of polices and their implementation, by and large, vary from one country to other based on the extent to which they:

- Integrated or subordinated ICTs to national aspirations and development plans
- Involved champions (experts) and secured commitment from the highest level (who initiated and drove the process)
- Addressed telecommunications and broadcasting sector reforms
- Involved key stakeholders, especially civil society organizations and the private sector in the definition, elaboration and implementation

- Undertook assessment to inform policy development
- Paid attention to the capacities of government and other instrument to implement the policies and carry on with the iterative process

These factors determine the extent to which African countries can adopt and implement ICT policies.

Policy implementation remains one of the key issues in many developing countries in Africa particularly given the fact that while many countries have a national ICT policy in place, very little progress has, in most cases, been achieved in policy implementation. African countries are generally faced by dichotomy in ICT policy in that while national ICT policy are aimed to deliver broader social-economic outcomes for the entire country, sectoral reforms are primarily aimed at ensuring particular objectives of a sector primarily driven by minority business interest and this creates a situation of potentially conflicting goals for policy makers and thus resulting into an impasse when it comes to policy implementation. This helps to explain the situation where a majority of African countries that have completed an ICT policy have not made any progress on its implementation even when the policy has been in place for more than three years (Njuguna, 2006).

This impasse in formulation and implementation of ICT policy can be traced to the unique situation faced by developing countries where developing countries in African have to address wide social-economical development objectives such as those outlined in the millennium report on one hand and the ICT sector issues such as privatization, liberalization, and regulatory concerns on the other (Njuguna, 2006).

Sarkar De (2005) identifies the problems associated with the adequate implementation of ICT policies, particularly in developing countries (including African countries) as follows:

- The government identifies ICT as tool for developments, but most of the polices result in sectoral development of ICT in software rather than focusing on social induced development
- Most countries do not have definitive national ICT development master plan
- There is a lack of availability as well as unbalanced distribution of information and telecommunication infrastructure in most of the countries
- Various studies have revealed that people's awareness and knowledge of the benefits of ICT is very low and needs to be enhanced
- Inability of the countries to keep pace with the continuous and rapid speed of ICT innovation and development

FUTURE TRENDS

There is steady growth in the number of African countries that have formulated ICT policies. It is hoped before long that all 54 countries in African will have national ICT polices. An ICT framework is generally recognized as a necessary step in order to create an enabling environment for the development of ICTs and their uses to enhance economic development and better social outcome (Njuguna, 2006). As more African countries developed ICT polices, the economic, social, and other sectors of the continents are sure to improve tremendously. Research on how African countries can adequately implement ICT polices in needed to enable the continent reap the benefits of ICT policies. Research on attitudes of government officials towards ICT policy formulation and implementation could be conducted, the outcome of which could help to assists different African counties to improve their policy status.

CONCLUSION

ICT policies enable countries to articulate measures that can enable them use ICTs to enhance the development of the different sectors of the society. Several African countries have already formulated national ICT policies. However effective steps have not yet been taken in most cases towards implementation of the policies. Concerted efforts should be made by countries that are yet to devise policy to formulate one. All African countries that have formulated ICT policy must take concrete steps to implement them. One of such steps could be for the governments to establish an agency which should be responsible for planning for and monitoring ICT policy implementation strategies. The governments can also set a time frame for the actualization of the statements of intensions expressed in the policies. ICTs are always evolving, so there is need for periodic revision of formulated ICT policies in order to take care of new developments and meet new realities of life.

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KEYWORDS

Globalization: This refers to the current state of worldwide integration, interdependent and interconnectivity in social political, cultural, economic, and ecological areas of life and made possible through deployment of and utilization of ICTs.

Information and Communication Infrastructures: These are systems/frameworks such as telecommunication and computer networks intended to facilitate transmission/exchange of information.

Information Society: This refers to a society in which the creation storage, processing, distribution, exchange, diffusion, use, and manipulation of information is central to every social, political, cultural, economic, and ecological activity.

Local Production: This involves the manufacture of ICT software and hardware within the country.

Sectoral Application: This has to do with the different spheres of the country which an ICT policy addresses and to which the policy can be applied.

Telecommunications: Electronics systems/technology used for transmitting messages over a short/long distance by radio, telegraph, cable, television, satellite, and so forth.

Voice Over Internet Protocol (VoIP): This involves the sending /exchange of voice conversation over the Internet.

ICT Processes for Virtual Academic Research Teams (VART) in Academia

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INTRODUCTION

In recent years, there has been increasing interest among managerial researchers in the phenomenon of *virtual teams*. The growth of the Internet along with other forms of information communications technology (ICT) have resulted in the adoption of geographically dispersed networks by businesses in an effort to maximize the utilization of expertise within organizations. Academics have been quick to notice this trend. Thus, a large number of written articles examine the impacts of these new teams on organizational structure, technology utilization, and team processes. However, academics have been slower to notice the changes that ICT have had on the way research is performed. While some work has been done describing the emergence of large formalized electronic networks of international scholars, these studies tend to dismiss the formation of small groups of scholars as irrelevant (Milliman & Glinow, 1998a, 1998b; Teagarden, Von Glinow, Bowen, Frayne, et al., 1995).

The purpose of this chapter is to bring these smaller self-forming, informal academic research teams into focus to understand the effects of ICT and associated processes which have emerged to support such formations. In addition, the identification of different traits within the small teams will be noted. This chapter will provide insight about *virtual academic research teams (VART)* based on the literature to date in this area as well as some insights about VARTs from two recent exploratory empirical studies (Carroll & Lecoure, 2005; Lecoure & Carroll, 2004). Specifically, it will address questions relating to the ways in which these teams come about, the different types of virtual research teams that exist, and the possible practices which result in the success these teams.

THE EVOLUTION OF VARTs

Understanding Virtual Teams

Advances in information technology over the past decades have increased the number of teams in various settings working across time and space. This new organizational formation has heightened interest by both academics and practitioners to explore virtual work teams. Although there is an increasing emphasis in the literature relating to the study of virtual teams, the work is still in its early stages of development (Powell, Piccoli, & Ives, 2004). The most prominent theme in the literature to date has focused on the challenges experienced by virtual teams, especially as relates to *media richness* and information communication technology tools (Andres, 2002; Maznevski & DiStefano, 2000; Powell et al., 2004). Specifically, this research has focused on the ways in which a business deals with the opportunities and challenges that are associated with the development of virtual teams and its effective use of information mediated technology. Studies have provided insights regarding the use of various communication channels from collaborative such as face to face, telephone, video conferencing, and instant messaging to asynchronous such as letters and e-mail (Majchrzak, Rice, Malhotra, King, & Ba, 2000; Pauleen, 2003; Townsend, DeMarie, & Hendrickson, 1996; Watson-Manheim, Chudoba, & Crowston, 2002). More recent works have begun to focus on areas such as team design, culture, training, relationship building, trust, communication, coordination, and task/technology structure fit.

Numerous definitions of a virtual team have been posited in the literature to date. Although variations exist between the definitions, most researchers agree in general terms that a virtual team is a group that is distributed and works across time and space using information communication technology (see Ahuja, Galletta, & Carley, 2003; Bell & Kozlowski, 2002; Jarvenpaa & Leidner, 1999; Lipnack & Stamps, 1999; Manzevski & Chudoba, 2000; Powell et al., 2004; Wong & Burton, 2000). One issue that has arisen with respect to definitions and terms in this area is the semantics concerning the words "team" and "group." Both terms are used interchangeably. However, it has been noted by some researchers that the term team "should be reserved for those groups that display high levels of interdependency and integration among members" (Powell et al., 2004). Considering this distinction, this article will define a virtual team as a "group of people who interact through interdependent tasks guided by a common purpose that work across space, time and organizational boundaries with links strengthened by webs of communication technologies" (Lipnack & Stamps, 1997, p. 7).

Academic Research Teams

For the most part, past research on the academic research process predominantly focused on areas such as individual author, multiple authorship, interdisciplinary research, academic/practitioner research, academic journal, and topics. It has been speculated that the number of authors on a per article basis has increased in recent times due to the enablement of ICT and the development of associated processes (Milliman & Glinow, 1998a, 1998b; Nason & Pillutla, 1998). However, while it is generally believed that academics have begun to work virtually with colleagues using various forms of ICT, there is to date limited empirical evidence to support this assumption. Further, a closer examination of the effects of ICT on the academic research process is driven by two trends. First, with the globalization of business, the challenge in management research has become heightened to create a more international focus when addressing research questions around cross-cultural dimensions, team effectiveness, and other new topics as they emerge (Turati, Usai, & Ravagnani, 1998). Second, the vast developments in information communication technology have also changed the ways in which academics exchange, access, and compute information (Koku, Nazer, & Wellman, 2001). These two factors combined have provided both the ability and need for academics to work virtually. Although some academics have worked in *distributed groups* in the past, there are few studies examining the virtual academic research team (Milliman & Glinow, 1998a; Nason & Pillutla, 1998).

DYNAMICS OF VARTs

It must be acknowledged that an emerging stream of literature focuses on the *academic international research team (AIRT)*. Current published works around AIRT are limited and are aimed mainly at issues surrounding the planning and development of a model for large, organized, and funded consortiums (Nason & Pillutla, 1998; Teagarden et al., 1995). A review of the literature identified that most work was theoretical, case based, and speculative. Furthermore, in current research, the terms used to describe this phenomenon have not been consistent among authors in either description and/or definition. The overall review of the literature also identified that the individual virtual academic researchers have not been observed or studied to provide more general insights with respect to the VART experience.

A recent study attempted to address some of these gaps to provide more insights about VARTs. The following is an overview of the findings relating to both the increase in VARTs since the early 1990s as well as characteristics of VARTs identified through a qualitative case study with virtual academic researchers.

VART Trends

The rising trend in authors per article is unsurprising in light of the technological advances adopted within business and society over the last several decades. Even for researchers that work in single university teams, the ability to communicate outside of traditional office hours while having the use of asynchronous communication technologies allows for an even closer coordination of team tasks and the inclusion of additional researchers.

In a recent study of five leading academic organizational studies journals[1] (Lecoure & Carroll, 2004), there was a clear indication that multi-authorship has increased during the period between 1992–2001 (Figure 1). The rise in VART ratio appears to cut across both theoretical and quantitative works (see Figure 2). Significant trends in VART ratios were found in both the *Academy of Management Review*, which publishes theory pieces almost exclusively, and the *Academy of*

Figure 1. VRT ratio increase by year (© 2007, Wendy R. Carroll. Used with permission)

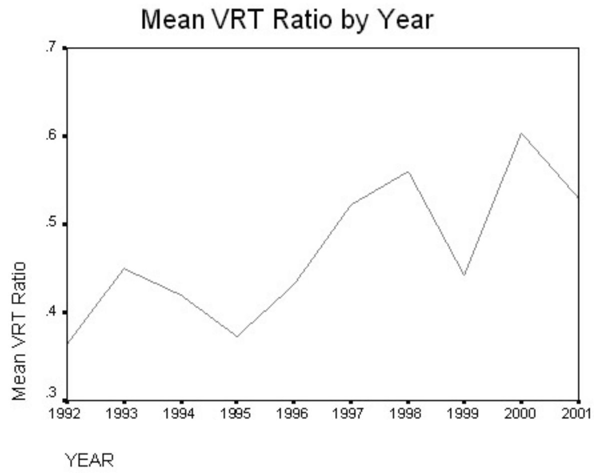
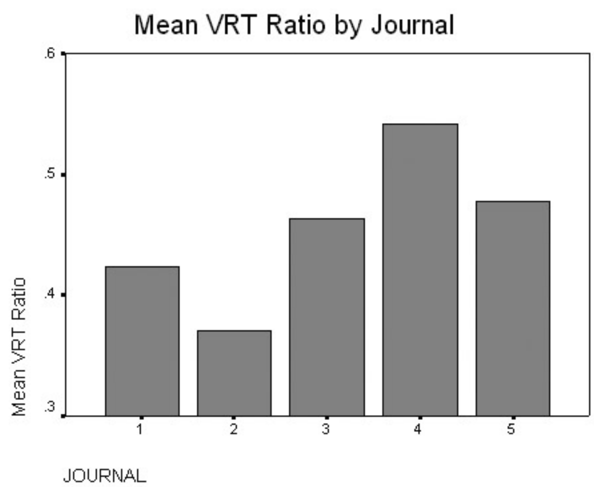


Figure 2. VRT ratios by journal (© 2007, Wendy R. Carroll. Used with permission)



Note:
1 = Administrative Science Quarterly
2 = Academy of Management Review
3 = Academy of Management Journal
4 = Strategic Management Journal
5 = Personnel Psychology

Management Journal, which has a quantitative focus. *Strategic Management*, which publishes both types of articles, was also found to have a significant trend in VART ratio. The analysis of the trend in VART ratio between journals provided one surprising result that is difficult to explain in light of other findings in this study. *Personal Psychology* had the highest mean author count (M=2.68, SD 1.32), but in the post-hoc analysis, the VART ratio was not found to change significantly over time.

While the measure of whether the authors of each individual article were working in a virtual team is simplistic and inclusive (it cannot discriminate on work done on sabbatical, "vacation" studies, or universities in close geographical proximity), the change in VART ratios over the decade from 1992 to 2001 suggests that there has been a slight, but significant, change in the way academics conduct their research. There are two possibilities that may help to explain the results of the data supported by another study described below (Carroll & Lecoure, 2005). The first possibility is that the recent and rapid proliferation of ICT has resulted in new research dyads and triads being formed, and it is based upon exposure to a wider group of academics for coworker selection purposes. A second possibility is that researchers who were co-located at one time in their careers are now able to continue their collegial relationships even after one or the other has moved on to a new institution. Also, mentor relationships may be extended temporally as mentors and their former graduate students are easily able to communicate through ICT technologies.

Characteristics of VARTs

An exploratory qualitative study suggested that VARTs have varying types of team formations and adoption of certain practices which further compliment ICT use and contribute to the overall success of a research project (Carroll & Lecoure, 2005). A case study of a single university was conducted to further explore this phenomenon. Two emerging themes developed from the study relating to VART formation and critical success factors which are described below.

VART Formations

Four types of VART formations were described by the participants in the study:

- Mentoring teams which are the continuance of the natural and traditional relationship of the thesis advisor and student beyond graduation. This relationship, when it continues, tends to be rather robust and long lasting.
- Expertise based team which is typified by the requirement of adding additional authors to fill skills gaps in the team. Typical expertise based teams are usually a fusion of strong theorists and writers with those who have strong statistical and analytical skills or teams that require an experienced manager due to their complexity.
- Common interest teams which differ from expertise based teams because the relationships are formed due to similar research interests. As expected, the majority of these types of teams begin at academic conferences or through mutual acquaintances. Very few of these teams form through the published work of one researcher being read by another, who "cold-calls" the author to see if they would like to work together. According to our interviewees, these types of teams are the most susceptible to breakdown. While research interest may be similar, methodologies and approaches often differ substantially. These relationships also suffer greatly from attrition because commitment and motivation to pursue the project differ between members.
- Collegial teams which like the mentor teams are fairly robust. The researchers have either worked together before or have long lasting personal or professional association. These teams often have a fixed and expected approach to how the research will be conducted. Unlike the common interest team, collegial teams have worked through their methodological differences through successful negotiations in previous team formations.

The collegial teams and mentor teams appear to provide a strong cohesive nucleus. Additional researchers can be added to form new expert teams or common interest teams. However, the success of this new team seems dependent on the same variables discussed in relation to the success factors of newly formed teams.

Critical Success Factors

Several behavioral practices that may relate to VART success have been posited based on this recent study

(Carroll & Lecoure, 2005). These practices apply primarily to research conducted by new virtual research teams or existing virtual research teams to which new members have been added:

- **Planning:** Strategic planning should be done in face to face meetings. While experienced VARTs seem able to plan remotely, new teams seem to require face to face meetings to ensure there is mutual understanding of the research question, methodology, role expectations, and timeline.
- **Role clarity:** The role of each team member should be clearly defined through negotiation at the beginning of the project. Authorship order should be determined during this process.
- **Commitment:** Commitment from each team member should be secured prior to the commencement of any VRT project. Members should recognize that the VRT will require a significant time investment and that members who are not fully committed may not fulfill obligations to the project.
- **Leadership:** A project champion who ensures that contributors meet deadlines and conform to group norms is essential to projects with large numbers of authors.
- **Task assignment:** A low interdependency of tasks is beneficial to the success of VRT projects. Clearly defined and discrete responsibilities on deliverables are required to streamline the VRT process and typically results in less opportunity for conflict.

CONCLUSION

The research presented in this article has provided some evidence to support that management researchers have changed the ways in which they have arranged themselves in research teams in the 10-year period between 1992 and 2001. Researchers are frequently choosing to work with colleagues from whom they are separated by institutional, geographic, and temporal boundaries. These changes have taken place primarily due to the changes in information communication technology during this time period and most notably due to the internet and e-mail. These changes have allowed for cost-effective, efficient, and instantaneous communication among academics, allowing them to choose research partners from all corners of the world. However, future research must continue to work towards understanding how and why these self-forming teams achieve successful outcomes.

NOTE

Journals included in this study: *Administrative Science Quarterly*; *Academy of Management Review*; *Academy of Management Journal*; *Strategic Management Journal*; Personnel Psychology as identified by *Starbucks Business Journal* and Book Citation Index.

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KEY TERMS

AIRT: Academic International Research Teams are normally formally established and work on research initiatives which involve several countries and cultures.

Distributed Groups: Refers to a group formation when members are y located in different geographic areas.

Media Richness: Refers to the amount of information which can be exchanged and transmitted through a specific communications channel such as telephone, email and face to face. Some channels provide for a stronger capability for exchanging information effectively.

VART: Virtual Academic Research Teams are both formally and informally establish teams that work in separate geographic locations and communicate with team members using information communication technologies.

VART Team Formations: Four types of team formations for VARTs as identified through an exploratory study which include mentor, expert, common interest and collegial.

Virtual Team: "A group of people who interact through interdependent tasks guided by a common purpose that work across space, time and organizational boundaries with links strengthened by webs of communication technologies" (Lipnack & Stamps, 1997, p. 7).

ICTs and Distance Education in Nigeria

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INTRODUCTION

Advances in information and communication technologies (ICTs) have posed complex problem for colleges and universities in Nigeria especially in their distance education programs (Ololube, 2006). Improving the quality of education through the diversification of contents and methods and promoting experimentation, innovation, the diffusion and sharing of information and best practices as well as policy dialogue are UNESCO's strategic objectives in education (UNESCO, 2002, 2005). As such, information and communication technologies (ICTs) literacy rate have become key tools that have a revolutionary impact on how we see the world and how we live in it. This phenomenon has given birth to the contemporary and advances in our ways of life. ICTs are having a revolutionary impact on educational methodology. However, this revolution is not widespread and needs to be strengthened to reach a large percentage of the population through distance education. In a complex society, many factors affect distance education. Hence an interdisciplinary and integrated approach is very necessary to ensure the successful development of Nigeria's economy and society (Mac-Ikemenjima, 2005).

The academic landscape in Nigeria includes the teaching and learning process, along with the educational programs and courses and the pedagogy or methodology of teaching; the research process, including dissemination and publication; libraries and information services; higher education administration and management, and distance education programs (Beebe, 2004). According to the national policy on education, in Federal Republic of Nigeria (1989), higher education refers to post-secondary section of the national education system which is given in universities, polytechnics and colleges of technologies including such courses as are given by colleges of education, correspondence colleges and such institutions as may be allied to them. The terms of references for these institutions of higher education through the national policy on education are:

- The acquisition, development and inculcation of the proper value-orientation for the survival of the individual and society.
- The development of intellectual capacities of individuals to understand and appreciate their environments
- The acquisition of both physical and intellectual skills which will enable individuals to develop into useful members of the community
- The acquisition of an objective view of the local and external environments (p. 22)

The Federal Republic of Nigeria (2004) through its national policy on education detailed that the goal of distance education should be to:

- Provide access to excellence education and equity in educational opportunities for those who otherwise would have been denied.
- Meet special needs of employers by mounting special certificate courses for their employees at their work place.
- Encourage internationalization especially of tertiary education curricula.
- Restructure the effect of internal and external brain drain in tertiary institutions by utilizing Nigerian experts as teachers regardless of their locations or places of work (p. 45)

Thus, the federal government is convinced that for higher education to make optimum contribution to national development, ICTs are essential ingredient to foster its implementation. Though, the integration of information and communication technologies (ICTs) in distance education programs in Africa has not been encouraging and has been the topic of a good deal of debate globally. Although in Nigeria, the relationship between the development of ICTs penetration and use in distance education programs and its diffusion into the programs in higher education is dependent upon a number of factors.

BACKGROUND

Regardless of the fact that there are relatively abundant researches on distance teaching and learning, studies on the impact of information and communication technologies (ICTs) on distance education in Nigeria are sparse. However, the use of ICTs by higher education institutions across the world is beginning to emerge fast over the last decade. Higher education institutions across the world have been adopting ICT teaching and learning technologies in an effort to create an environment for both students and their instructors to engage in collaborative learning environment and gain access to information (Ifinedo, 2006).

As such, every nation invests in education because it can produce unquantifiable benefits for individuals, organizations and the society as a whole. Education is provided through formal and informal means. In formal settings the conventional (face-to-face school instruction) and distance education (offered with separation in terms of physical location of instructors and students) have been used to provide educational opportunities to recipients. Open and distance education though not new in Nigeria has been given much prominence of recent. Many Nigerians benefited through the open education (correspondence) of Rapid Result College, and Exam Success Correspondence College, among others. It is also a means of providing access to basic information and tertiary education for Nigerians (Yusuf, 2006). Notwithstanding the keenness by the federal and state governments to guarantee open and distance education in Nigeria, the use and penetration of ICTs in distance education teaching and learning has been a major obstacle that may impede proper implementation of the program by institutions of higher learning. The evidence seem glaring that Nigeria is not yet ready in her preparedness to integrate ICTs in all spheres of her national economy.

For example, a recent study conducted by the Global Information Technology (2005), the report used the Networked Readiness Index (NRI), covering a total of 115 economies in 2005-2006, to measure the degree of preparation of a nation or community to participate in and benefit from ICT developments. Nigeria was ranked 90th out of the 115 countries surveyed. United States of America topped the list, followed by Singapore, Denmark, Iceland, Finland, Canada, Taiwan, Sweden, Switzerland and the United Kingdom, etc. Likewise, Nigeria was ranked 86th out of 104 countries surveyed in 2004 which still shows a decline in Nigeria's preparedness to participate in and from ICT developments. Similarly, a study by Nigerian Information Technology Professionals in America in 2002 indicated that given current ICT penetration it may take Nigeria 50 years to catch up with America on the aspect of Pc count per households (Iromanto in Yusuf, 2006).

Information and communication technologies (ICTs) are indispensable and have been accepted as part of the contemporary world especially in the industrialized societies. In fact, cultures and societies are adjusted to meet the challenges of the knowledge age. The pervasiveness of ICT has brought about rapid changes in technology, social, political, and global economic transformation. However, the domain of distance education has not been unaffected by the penetrating influence of information and communication technology. Unquestionably, ICTs has impacted on the quality and quantity of teaching, learning, and research in distance education. Therefore, ICT provides opportunities for distance education students, academic and non-academic staff to communicate with one another more effectively during formal and informal teaching and learning (Yusuf, 2005). For this reason, distance education programs in Nigeria need to integrate ICTs into their agendas, because the quality of teaching using ICTs to gain access to information is known in virtually all countries to be a key predictor of quality student learning. Therefore, effective manpower training is crucial using ICTs, because ICTs are tools that on the one hand can facilitates human resources development, and on the other hand, helps us to take full advantage of the potential of technology to enhance quality student learning via distance education (UNESCO, 2003).

THE NATIONAL OPEN AND DISTANCE EDUCATION UNIVERSITY OF NIGERIA

The National Open and Distance Education University of Nigeria (NODEUN) first began in 1983 but was suspended in 1985 by the then military government. The resuscitation of NODEUN is part of the commitment of the present government towards Universal Basic Education. The justifications for the establishment of the Open University are clear because there are approximately 1.5 million applications per year who fight for a place to attend university. However, the University system can only accommodate 20% of this number. The course delivery of the Open University will be through a combination of web-based modules, textual materials, audio and video tapes as well as CD ROMs. The university currently has 18 study centers and plans to have at least one study center in each of the 774 local governments of Nigeria. It runs programs in education, arts and humanities, business and human resource management and science and technology (Mac-Ikemenjima, 2005). Prior to the Open University, the National Teachers' Institute (NTI) was the first institution specifically established by Federal Government to provide distance education courses designed to upgrade under-qualified and unqualified teachers. NTI also introduced the Nigerian Certificate in Education (NCE) by distance learning in 1990 (COL International, 2001).

In the same vein, given that the demand for access to higher education and university education in particular are higher than can be accommodated effectively. The existing institutions are presently operating beyond their capacities. The University of Abuja, which is centrally located in the Federal Capital Territory, was mandated by law to offer distance learning throughout the country. It was originally intended to operate as an Open University. As a first step to this end, the University set up a Center for Distance and Continuing Education (CDLCE). An assessment conducted in August 1999 of the available resources for delivering distance education at the CDLCE indicated that the available facilities are inadequate for both present and future needs (Moja, 2000).

PURPOSE OF THE STUDY

In Nigeria, we acknowledge that more than a few factors affect the integration and approach to successful improvement of distance education programs. Since this is the case, it was reasonably impossible to consider all the factors. Therefore, the purpose of this study is not to look into such several factors but to address the impact of ICTs in relation to distance education, and relate it to sustainable development of education in Nigeria. The key assertion of this paper is that the effective use of ICTs for distance education addresses both the problem and solution to technology based learning, seeking synergistic results that benefit distance education students as they graduate and carry out their duties.

Despite the keenness by institutions of higher learning to establish distance education programs, they are confronted with enormous problems that may impede proper implementation. Some of these problems are: Poor ICTs penetration and usage among Nigerian distance education practitioners. Approximately almost all African countries basic ICTs infrastructures are inadequate; this is as a result of problem of electricity to power the ICTs materials, poor telecommunication facilities, poor postal system and lacks of access to the needed infrastructures is made awkward because of insufficient funds.

According to Yusuf (2006), since successful distance education cannot be assured without the use of communication and technological tools (e-mail, fax, Internet, television, radio, etc.). Several cities and rural areas in Nigeria are yet to have or have fluctuation in electricity supply. Just like electricity most Nigerians do not have access to telephone and other telecommunication facilities. Even, telephone lines in the urban centres are not adequate to serve the teeming population. Services for those who have access are in most cases epileptic. These may make the integration of telecommunication in the delivery of distance education difficult. In addition, poor state of telephone has led to increase in dial-up cost for most Nigerians. Even with the recent introduction of GSM in August, 2001, access is still limited and services are yet to be perfect and service charge may make GSM unattractive for distant learners. Poor economic situations and its effects on middle level manpower, stands as the major obstacle towards the implementation of ICTs in distance education. Even an average middle income earner cannot afford basic technological and communication gadgets. Thus, computer related telecommunication facilities might not be useful for most Nigerians, as computer is still a luxury in institutions, offices and homes. This has made the integration of necessary on-line resources (e-mail, newsgroups, World Wide Web, etc.) into distance education in Nigeria most difficult.

CONCLUDING REMARKS

In recent times, formal education is entering and playing an increasing role in the competitive market in the global economy (Zajda, 1995). As such distance education should endeavour to ensure standardization and uniformity in meeting the global trends in the highly competitive demand for excellence in distance education programs aimed at producing highly qualified manpower need. The governments in Africa should embark on a comprehensive program of recapitalization of higher education. Therefore the governments should move from the traditional position of paying lip service or little attention to empowering higher education and distance education programs to a pro-active stands by funding, monitoring and controlling there implementation as a way of ensuring standard. Accordingly, making sure that adequate and functioning ICTs infrastructures are available, like electricity, telecom equipments and effective postal system and making these infrastructures accessible to organizers of distance education programs and its citizens at large.

Consequently, there is the need to better design distance education curricula and infrastructure as well as organization of programs so that management and students can better plan for unanticipated and unintended results that confront them as they operate. Because ICTs play a key role as enabler to help us better manage the complex information flow and to integrate such information towards effective policy formulation and planning towards the utmost maximization of human capital and potential in society. Thus, it involves the development of effective and integrated tools as well as training modules to enable their application through effective distance education agendas (Mac-Ikemenjima, 2005).

This research study made use of secondary data sources; therefore they are subject to distortion. No researcher is independent of his or her own normative evaluation of a research problem, as such, if any part of this analysis should bear the hallmark of the researchers stance, they should be overlooked and considered as part of the researchers own over-sight. Because of some methodological weaknesses associated with qualitative research, a quantitative survey is highly encouraged using the themes of this study and other deprivations in assessing the impact of ICTs on distance education in Africa in general and Nigeria in particular. This is not supposed to say that quantitative research studies are without constraints.

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KEYWORDS

Access of Information through ICTs: The amount of information accessible to individuals to support them in trying new strategies, thinking and creativity that are reflective in practice aimed at engaging them to new innovations through the use of ICTs.

Excellence: Excellence in this paradigm is a generally accepted best ways of doing things in education in search of distinction in teaching and learning situations. It is an essential component of best practice that creates quality teaching strategies that produces improved scholarship.

ICT: Information and communication technologies (ICTs) are advances in technologies that provide a rich global resource and collaborative environment for dissemination of ICT literacy materials, interactive discussions, research information, and international exchange of ideas, which are critical for advancing meaningful educational initiatives, training high skilled labor force, and understanding issues related to economic development. ICTs highlight innovative efforts and partnerships and promote ICTs literacy, and facilitate interaction between all sectors of a national economy including external spheres.

ICT Competencies: Involves but not restricted to the use an online catalogue to identify and locate resources for a specific information need, keyword search strategies to refine operational situations, browser and search engine to locate and retrieve appropriate information and the use of other ICTs instructional materials that aid teaching and learning situations

ICT Literacy: The capability (knowledge, skills, and aptitude) of a person to identify, search effectively and present specific information in order to build knowledge and develop critical and creative thinking pertinent to a field of study.

Open and Distance Education: Distance education, also called open or distance learning is a form of education in which there is normally a separation between teachers and learners. Thus, it includes one which others may refer to as a means of the printed and written word, the telephone, computer conferencing or teleconferencing used to bridge the physical gap between the instructor and the learner. Distance education equally involves the provision of whatever educational opportunities that are needed by anyone, anywhere, at any time for those who otherwise would have been denied.

Standard: Standard in this context is the degree of excellence required for a particular purpose; it is an accepted or approved example against which phenomenon are judged or measured.

The Impact of Technological Frames on Knowledge Management Procedures

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INTRODUCTION

This article intended to explore technological frames held by organisational group members that implicitly served to shape their interpretations of events to give meaning and deliver actions in knowledge management procedures. The research used the existing technological frame (Orlikowski & Gash, 1994) concept to interpret the social aspect of the problems associated with the introduction and utilisation of information technology in conducting knowledge management systems. This research was carried out in the context of four different industries in Taiwan and four cases based on each industry were chosen.

BACKGROUND

During the previous two decades, information systems and information technology have become the key factors of organisational development (Brancheau & Wetherbe, 1990). This trend has been demonstrated by a significant number of successful and unsuccessful cases (Ginzberg, 1981) of several different organisations around the world which are using information technology. All of these cases support the belief that organisations outperforming competitors in the business world are those using state-of-art technologies efficiently (Brancheau & Wetherbe, 1990). This research identified the elements of diagnosis and presented recommendations to incorporate information technology into organisations and successfully developed competitiveness and productivity elements in the business functions context.

With the advent of the age of knowledge economics, organisations utilise information technology in order to survive in a dynamic challenging environment. While adopting knowledge management systems within firms has become the trend in Taiwan, education of employees to be familiar with modern technology remains important.

Individual vision on technological phenomena provides strategies devised by organisational top management with meaning. Each individual establishes some strategies to observe, understand, and use technology. These strategies have been re-created in literature as a 'technological frame.' This term comes from a revision of technological phenomena in the social scope, in which the common perspective and technology social construction are analysed. Technological frame means an individual's interpretation of technology and how they shape their behaviour toward it. This term originally comes from Orlikowski and Gash (1994) who set the groundwork for a sociocognitive approach toward information technology. The main point is that an understanding of an individual's interpretations of a technology is important in order to understand their interaction with technology. Therefore, in knowledge management procedures, individuals need to understand technologies before interacting with them, and during the sense-making processes, they develop particular assumptions, expectations, and knowledge of the technology, which then serves to shape subsequent actions toward technology (Orlikowski & Gash, 1994).

In most organisations, it is assumed only technologists can handle technologies effectively; other personnel such as high-middle level managers and other staff generally do not deal with it as effectively as technologists. This is because different group members within organisations have difficulties and conflicts around the development, use, and changes associated with technology (Orlikowski & Gash, 1994). As a result, research on technological frames among different group members in firms is necessary and valuable because research outcomes are useful and helpful when firms implement the knowledge management systems. This article focuses on exploring the impact of technological frames among different stakeholders linked to knowledge management procedures. By covering all potential group members of a knowledge management system, this research gained a better understanding of each individual's perceptions and expectations toward information technology and knowledge management.

TECHNOLOGICAL FRAMES

Researchers have examined a number of social, cognitive, and political processes in technological frames that influences knowledge management activities and outcomes. A theoretical approach that focuses on sense-making processes is helpful for investigating why participants in such activities understand requirements as they do (Davidson, 2002; Dougherty, 1992) and why their understanding of requirements may change and shift (El Sawy & Pauchant, 1988). Orlikowski and Gash (1994) develop the concept of technological frames of references as an analytic lens for examining how stakeholders' sociocognitive interpretations influence their action related to IT development and use in organisations.

Technological frames have powerful effects in that people's assumptions, expectations, and knowledge about the purpose, context, importance, and role of technology will strongly influence the choices made regarding the design and use of those technologies (Noble, 1986; Orlikowski, 1992; Pinch & Bijker, 1987). Because technologies are social artefacts, their material form and function will embody their sponsors' and developers' objectives, values, interests, and knowledge of that technology (Davidson, 2002; Orlikowski & Gash, 1994). For instance, views of how work should be done, what the division of labour should be, how much autonomy employees should have, and how integrated or separated production units should be, are all assumptions that are consciously or implicitly built into information technology by systems planners and designers (Boland, 1979; Hirschheim & Klein, 1989; Orlikowski, 1992).

VARIOUS KNOWLEDGE MANAGEMENT PERSPECTIVES

During the 1990s, knowledge has been viewed as a primary asset and knowledge management as a key differentiator between competing organisations (Drucker, 1995). As with the concept of knowledge, there has been a proliferation of attempts to define knowledge management in the literature and the choice of the best definition is a subjective judgment for each reader and author. Common in the literature are the constructs that define knowledge management as a process. In terms of organisational knowledge, these constructs can be summarised as creation, capture, storage, access, and transfer. Other common descriptors assigned to knowledge management are usage, recording, sharing, generation, and accumulation, or as been defined as procedure or activities.

Knowledge has limited value if it is not shared. The ability to integrate and apply specialised knowledge by organisation members is fundamental to a firm in creating and sustaining a competitive advantage (Grant, 1996). Knowledge management is managing the corporation's knowledge through a systemic and organisational specified process for acquiring, organising, sustaining, applying, sharing, and renewing both tacit and explicit knowledge by employees to enhance the organisational performance and create value (Alavi & Leidner, 1999; Allee, 1977; Davenport, De Long, & Beers, 1998; Lai & Chu, 2002). It is quite often that companies, particularly those that compete on the basis of services and expertise, facilitate the codification, collection, integration, and dissemination of organisational knowledge using computer systems because they can facilitate communication and information sharing (Alavi & Leidner, 1999; Lai & Chu, 2002).

Davenport et al. (1998) stated there were four kinds of knowledge management: (1) creating knowledge repositories in which knowledge can be retrieved easily; (2) improving knowledge access to facilitate its transfer between individuals; (3) enhancing a knowledge environment to conduct more effective knowledge creation, transfer, and use; and (4) managing knowledge as an asset and concern about how to increase the effective use of knowledge assets over time. According to Malhotra (1998, p. 59), "knowledge management caters to the critical issues of organisation adaptation, survival and competence in the face of increasingly discontinuous environmental change" and adding that managing knowledge embodies processes that seek to combine the "data and information processing capacity of information technologies" with "the creative and innovative capacity of human beings."

Nonaka (1991) highlighted the importance of knowledge management in today's globally competitive market place when he stated successful companies are those that consistently create new knowledge, disseminate it widely throughout the organisation, and quickly embody it in new technologies and products. The area of knowledge management is an overarching strategy designed to leverage an organisation's capacity for creating and communicating knowledge as a resource that can create global strategic competitive advantage (Tucker, Meyer, & Westerman, 1996). It is facilitated by the development of a learning organisation that processes the ability to manage its knowledge assets and transfer that knowledge quickly and efficiently (Garvin, 1993). Organisational learning relies upon sharing knowledge and insights by building on past knowledge, experience, and learning of its people (Stata, 1989). The functional role of knowledge management is to bring formality to these concepts through an interactive process.

TECHNOLOGICAL FRAMES FROM AN ORGANISATIONAL PERSPECTIVE

An overview of studies conducted to identify the factors leading to information technology's successful implementation and use in organisations usually makes reference to top management directives concerning technology, alignment of the business strategic plan to IT plan, market strategies development using information technology, frequency of technology use, and process improvement by computer science, which involves an understanding of the business linked to information technology.

While this IT vision is a 'sine qua non' condition to develop new options in the organisational business context, it is also an essential part of an individual's perspective vision about technology (Cano, 2000) because through information technology, the actions and possibilities usually advised and planned by top management will be made easy. Therefore, an individual's vision about technological phenomenon provides the strategies devised by organisational top management with meaning. Each individual establishes some way to observe, understand, and use technology, and each way has been recreated in literature as a technological frame. This term comes from a revision of technological phenomenon in the social scope whereby the common perspective and technology social construction is analysed.

KNOWLEDGE MANAGEMENT FROM AN ORGANISATIONAL PERSPECTIVE

The evolution from data to information and from information to knowledge has played a leading role in shaping how organisations develop strategies and plans for the future. Many researchers believe that successful organisations that forge ahead in a rapidly changing business environment will do so through creating and sharing the new knowledge. Thus, organisational learning from a knowledge management perspective provides the opportunity for the goals and objectives of the organisation to be cultivated simultaneously with the goals and objectives of the individuals (COIL, 1999). Specifically, individuals are important to the learning process within the organisation, but organisational learning cannot be reduced to individual learning (Levine, 2001).

Within an organisational learning context, an ecological approach to knowledge management has been explored by Davenport's (1997) research on information ecology, which calls for communities of practice to be involved in the establishment of an ecological model that is holistically managed within an organisation. The human-centred information management model described by Davenport (1997) focuses on the information environment, the organisational environment that surrounds it, and the external environment of the marketplace. In this model, primary importance is placed on the people within the organisation, in terms of their strategic use of information, information politics, and the culture and behaviour of individuals within an organisation (Davenport, 1997).

According to COIL (1999), an ecological approach to knowledge management is based on the assumption that the accumulation of data is influenced by the core values of organisations, and that through some process of human interaction and context, including the use of computers to access and review the data, these data then take on significance and importance as information. Next, through the process of context, accumulation of data, sense making, synthesis, and reflection, this information is transformed and converted to knowledge that is relevant to decision making within the organisation, which then may or may not produce an action step but does influence the next round of data accumulation (Brown, Collins, & Duguid, 1989; COIL, 1999; Johnson, 1996). For instance, it might be that use of information may change the organisation in terms of producing more effective decision making, or that a transformation occurs within the organisational structure in the process of using the information itself (COIL, 1999).

Another ecological model, the knowledge ecology model, has at its core an active, interdependent, and complex adaptive system that adds an innately systemic dimension to the knowledge and learning that occurs within the organisation (Brown, 2000; COIL, 1999; Sveiby, 1997). Within a knowledge ecology perspective is the accumulated expertise and learning within the ecosystem, where ideas are exchanged, innovation blossoms, and value is added to information, thus producing new knowledge to test and apply in the internal and external environment, predominantly through the use of information systems (COIL, 1999).

BRIEF DESCRIPTIONS OF FOUR CASES

The cases collected include two IT-related firms, one consulting firm and one division within a local city council. All cases are highly knowledge-intensive. Table 1 provides a brief description of each case, in terms of its business type, stimulus for knowledge management strategies, and objectives of this research related to each case. Three of the four cases were stimulated by competition to begin a knowledge management campaign. Case D is a division within a local city council. Providing information to the public and utilising the knowledge management system within the city council are division's main functions. Leveraging knowledge by sharing was a very common objective for consulting firms. For example, case C shared knowledge in order to speed up deliveries to customers and develop management through leadership. In addition, case C sought to provide high quality business results to clients and increase profits by enhancing knowledge sharing and leveraging environment. Knowledge and expertise were the most important assets for case C and therefore how to capture and leverage knowledge were critical issues. Many consulting firms began by collecting experiences and the best knowledge management practices.

For companies in the high-technology industry, the stimulus for a knowledge management campaign was diverse. Case B focused on managing intellectual capital and wanted to improve knowledge utilisation more efficiently and effectively. More precisely, case B attempted to link intellectual capital with strategies and to leverage technology for global collaboration and knowledge sharing. Differing from case B, case A held a series of workshops to understand the current status of knowledge management within its business units and built an expert network and provided the appropriate experts for their clients who called for help.

Table 1. Brief descriptions of four cases

Firms	Business	Stimulus in develops KM	Objectives of KM in the firm
A	High-technology	Competition	To identify and integrate KM efforts among business units
B	High-technology	Competition	To find and apply methodologies to generate and use knowledge faster and more efficiently
C	Consulting	Competition	To create an environment of sharing knowledge to provide high quality solutions and increase profit
D	Information provider	Opportunity of providing knowledge	To help personnel gain access to external expertise and information by providing people-technology hybrid service

KNOWLEDGE MANAGEMENT PROCEDURES WITHIN CASES

The practical knowledge management procedures within each of the four cases consist of five processes: initiation, generation, modeling, storage, and transfer.

Initiation

The practices related to initiation were analysed from three points of view: (1) person/group responsible; (2) activities for the purpose of building a knowledge management environment; and (3) methods to identify knowledge management topics and issues. Comparisons at the initiation stage for the four cases are shown in Table 2.

1. *Authorities Responsible for KM Projects*

Similar to CEO, CFO, and CIO, a new position was created in case D—Chief Knowledge Officer (CKO). Meanwhile, case B created an intellectual capital management (ICM) team to institutionalise knowledge management and make it more formal throughout the whole organisation. By contrast, case A and case C did not set up any positions responsible for knowledge management project initiation; instead, the KM project was supervised under the business division.

2. *Activities to Build a KM Environment*

Once knowledge management was initiated, cases created an environment to facilitate direct knowledge management activities. This might involve creating an awareness of the need for knowledge management, setting standards, or finding appropriate persons to be facilitators.

The reviewed literature suggested that the creation of a climate of change and making those organisation members aware of the need for knowledge management are important. Only case A reported holding some activities toward this purpose by arranging workshops to understand the existing knowledge management projects within business units. Cases C and D provided some successful "stories" of leveraging knowledge in order to motivate personnel.

Previous research also suggests that it is important to set up a common language and standard to easily integrate knowledge management efforts within business units. Case A and case B reported having set up a standard. Twenty business units within case A launched various degrees of knowledge management projects. In order to integrate these knowledge management efforts, case A established a specific vocabulary and a management framework for knowledge management. Case B developed a structure of competency types and levels and defined the competencies required for particular jobs. These two efforts became the foundation for deciding the learning offerings for every employee. Case C assigned facilitators to each knowledge management network to smooth the knowledge management activities, and this was regarded as a key to the success of these networks.

3. *Methods to Identify KM Topics and Issues*

Four cases identified knowledge management topics and issues by setting up a pilot program (or its equivalent), as a most popular solution. Cases B, C, and D all chose

Table 2. Case comparison: Initiation stage

	Who responsible	**Activities to build a KM environment**			**Methods to identify KM topics & issues**		
Cases	Authority	'Warm-up'	Standards	Facilitators	Pilot Program	Workshop	Business strategy
A	No	workshop	Yes	No	No	Yes	Yes
B	ICM team	No	Yes	No	Yes	No	No
C	No	'story'	No	Yes	Yes	No	No
D	CKO	'story'	No	No	Yes	No	No

Table 3. Case comparison: Generation stage

	Team		**Knowledge identification**
Cases	Formal knowledge group	Learning community	How and where to identify knowledge
A	No	Yes	• Developing a structure of competencies • Identifying the competencies required for jobs • Evaluating the competencies of each employee
B	No	Yes	• Setting criteria to identify intellectual capitals • Locating knowledge from discussion forums • Capturing the decisions and the rationale from the structure conversations in the issue-base structured collaboration
C	No	Yes	• Creating anecdotal stories from learning in the community • Developing a project snapshot • Drawing a knowledge map
D	Knowledge network	No	• Identifying subject experts and then keep tracking • Identifying knowledge from the discussions among the experts • Developing a knowledge architecture and taxonomy as the focus of the KM effort

this method in order to produce an incremental process in the initiation stage. Case A had several independent knowledge management projects within each branch, such as a corporate education organisation (CEO) in its personnel division, product processes organisation (PPO), and computer product organisation (CPO) in the development division. All of these sub-organisations functioned as a ‘pusher’ in its knowledge management strategy.

Topic objectives used to launch the knowledge management campaign could be: to improve product development and anticipate customer needs; to boost creative problem solving; to reach a new level of customer focus, of intimacy, loyalty and enhanced relationships with customers. The criteria adopted by case A included finding the topic that had the most immediate, tangible result. It should be noticed that this exploration was based upon a corporate strategy.

Generation

This stage was concerned with the generation of knowledge, and the practices of all cases can be discussed from two points of view: team and knowledge identified issues, which are identified from the four firms’ practices. The first issue was the type of team responsible for the knowledge management projects. The second issue was how and where firms identify knowledge.

1. **Teams:** Of all of the cases, case D was the only one to organise a formal knowledge network for each key domain of knowledge and knowledge focus groups for specific topics such as shared corporate services in Taiwan practices. The learning community, a Web-based forum discussing any issues within firm for all personnel, was another form of a team used to gather and generate knowledge, as for cases A, B, and C. These groups or teams regularly set up a virtual meeting via an online information system. For example, the corporate education organisation at case A built an online discussion database in which the instructors delivered the value of the course materials to employees.
2. **Identifying knowledge:** Each case had different approaches to identifying knowledge. Case A developed a structure of competencies to assess each employee's ability by competing with each other to leverage the potential expertise of employees. Case B used multiple forums, such as professional forums, competency network forums, software asset forums, and project profile forums. The purpose of these forums was brainstorming to capture the point of each conversation. Case C drew a 'knowledge map,' which was a firmwide database to create expert profiles. Case D developed a knowledge 'architecture and taxonomy'—using a developed expertise search engine to ensure the effort on knowledge management was kept in the firm.

Modeling

This stage was concerned with the method of justifying and organising the generated knowledge. Due to the absence of justification criteria for these cases, the analysis focused on how each organisation structured their knowledge.

Methodologies are quite diverse. Any organisation may establish its own methods to classify knowledge. For example, case D developed knowledge architecture to specify the categories and terms for searching database and document files, while case B preferred to organise knowledge following the thesaurus approach and search using the keyword approach rather than categories. Organisations which established a learning community to capture feedback from fellow staff included case C. Case A built up a database into business categories by developing practice content and diagnose tools.

Storage

Storage stage involves holding much diverse information as discussion results, employee skills/expertise, and

Table 4. Case comparison: Modeling stage

Cases	Method
A	• Organising calls to the database into business categories • Developing best practices content and diagnostic tools
B	• Organising knowledge using the thesaurus approach and search by keyword • Providing standardisation and methodology to capture and retrieve information
C	• Structuring discussions in learning communities • Establishing a mechanism for capturing feedback from anecdotal stories
D	• Developing knowledge architecture based on knowledge taxonomy • Creating new models to evaluate and describe competencies

Table 5. Case comparison: Storage stage

Cases	Discussion	Best practice	FAQ	Skill/ Expertise	Others	Maintenance
A	Yes	Yes	Yes	Expert profiles	No	Community members
B	Yes	Yes	Yes	General intellectual capital repository	• Research database • Market & customer information	Knowledge engineers
C	Yes	Yes	Yes	Consultant skill	• Qualification • Sales presentation • Proposal template	IT staff
D	Yes	Yes	Yes	Knowledge profile	• Library of best thinking	Outsourcing

best practices. Skills and expertise are the most popular content stored, and selected cases all had their own expertise profiles. Best practice was another popular content; cases A, B, and C all created their own storage. In addition, the storage maintenance became routine, except that case D used outsourcing for storage, while other cases were maintained by internal staff. Other than the main approaches to knowledge storage, all cases had their own daily discussions regarding practical issues and then developed a set of frequently asked questions (FAQ) for general inquiries. The other form of storage such as a research database, proposal template, and library of best thinking were also adopted among cases except case A. The maintenance of storage was mainly conducted by internal staff, while case D was outsourced.

Transfer

The fundamental method for leveraging knowledge was to share knowledge through distribution and transfer. Some specific terms appear in the Table 6 in the 'system' and 'platform' columns, and these refer to software packages and integrated systems.

Lotus© Notes is a groupware application developed by Lotus, now part of IBM. Notes was one of the first applications to support a distributed database of documents that could be accessed by users across a local area network or wide area network. Its sophisticated replication features enable users to work with local copies of documents and have their modifications propagated throughout an entire corporate network.

Exchange Server, the Microsoft messaging and collaboration server, is software that runs on servers that enables personnel to send and receive electronic mail and other forms of interactive communication through computer networks. Designed to interoperate with a software client application, such as Microsoft© Outlook, Exchange Server also interoperates with Outlook Express and other e-mail client applications.

1. *Systems and Platform*

Many applications were adopted by cases. Each case had its own application, such as ICM AssetWeb collaboration systems in case B. However, most systems were based on Lotus© Notes for storing, retrieving, and distributing knowledge. The exception was case D, which adopted Microsoft© Exchange.

2. *Channels for Transfer*

It was not surprising that all cases shared their knowledge through an IT infrastructure because IT is an important enabler of knowledge sharing and transferring. In addition to the IT infrastructure, human interactions are also important. Explicit knowledge can be stored and transferred through IT equipment. However, tacit knowledge can only be shared through human interaction. Thus, human interaction was adopted as well in all cases. For instance, case C suggested that better performance might result from transferring knowledge through discussions within learning teams, even though explicit knowledge could be kept in the repository. Similarly, case D suggested that people were the most effective channel to exchange information and knowledge. Therefore, it was advised to encourage clients/employees to interact with experts/professionals to get a better result rather than clients/employees to access the repository by themselves especially when staff were not familiar with it.

RECOMMENDATIONS FOR FURTHER RESEARCH

It is expected that further empirical investigations will elaborate and extend the domains of technological frames, adding both domains that apply to technology in general and those that reflect particular kinds of technologies and specific organisational contexts. For instance, the fieldwork can be carried out among organisation members who are involved in new project development. The knowledge created can therefore be optimised for new project design and development.

CONCLUSION

This research had developed the concept of technological frames and suggested that personnel's technological frames influence actions toward technology in a knowledge management context. In addition, the research further assumed that technological frames are shared by members of a group having a particular interaction with some technology. In addition, this research defined the concept of frame incongruence and suggested that different group members may have incongruent technological frames, which could lead to difficulties around technology implementation and deployment. Different technological frames imply different ways of knowing and making sense of technology. As these different interpretations are typically not articulated or discussed, as in the chosen case of the Lotus© Notes (or Microsoft© Exchange) implementation, result un-

Table 6. Case comparison: Transfer stage

Cases	Systems	Platform	Human interaction
A	Accelerated Solution Environment	Lotus© Notes	Discussions between knowledge networks
B	ICM AssetWeb	Lotus© Notes	Discussion forums
C	Global Best Practices Knowledge Base	Lotus© Notes	Discussions in learning communities
D	KnowledgeScope	Microsoft© Exchange	With knowledge analysis

intentionally and unknowingly in misaligned expectations (such as technologists intending improvements in group work while users perceive improvements in individual productivity), opposing actions (such as technologists installing and operating a technology while users wait for training and applications), and unanticipated organisational consequences (such as resistance, scepticism, and irregular adoption).

By articulating the interaction between shared interpretations, social action, and technological artefacts within an organisational context, technological frames offer a number of theoretical and practical contributions. It is believed that the concept of technological frames and the broad domains of technological frames proposed are useful for examining key members' interpretations of technology and the nature and extent of differences among them. It is also argued that the framework of technological frames has utility for the diagnosis, explanation, and anticipation of outcomes around technological change in organisations, and hence may be particularly useful to implementers and practitioners attempting to manage such change processes.

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KEY TERMS

Frames: Generally referred to as “frames of reference” or “cognitive structures” in the field of psychology. Krippendorff (1986) defines them as the context, point of view, set of presuppositions, assumptions, evaluative criteria form a cognitive system with which a person perceives, judges or selectively constrains a course of actions or outcome thereof or with which a scientific observer delineates the subject matter of his theory.

Knowledge Management (KM): Malhotra (1998) stated KM caters to the critical issues of organisational adoption, survival, and competence in face of increasingly discontinuous environmental change. Essentially, it embodies organisational processes that seek synergistic combination of data and information processing capacity of information technologies and the creative and innovative capacity of human beings.

Knowledge Management Procedures: Refers to the process in knowledge management and can be summarized as creation, acquisition, storage, sharing, and transfer (Bassie, 1997; Davenport, Jarvenpaa, & Beers, 1996; Davenport & Prusak, 1998; Dilnutt, 2000; Drucker, 1985; Mayo, 1998; Murray & Myers, 1997; Nonaka & Takeuchi, 1995; Sveiby, 1997).

Organisational Learning: Huber (1991) defined as a change in the range of an organisation's potential behaviors, which may or may not contribute to enhance effectiveness.

Stakeholders: Refers to a large group of individuals in organizations. Orlikowski and Gash (1994) briefly divided stakeholders into managers, technologists, and users.

Technological Frames: Orlikowski and Gash (1994) use "technological frame" to identify the subset of members' organizational frames that concern the assumptions, expectations, and knowledge they use to understand technology in organizations. This includes not only the nature and role of technology itself, but also the specific conditions, applications, and consequences of that technology in particular contexts.

The Implementation of Practices with ICT as a New Teaching–Learning Paradigm

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INTRODUCTION

Information and communication technology (ICT) is today influencing many aspects of our lives from administration to economy from culture and entertainment to work, and so forth. Education is receiving from IT and ICT a great deal of suggestions just from their first beginning. It is well known, for example, that Taylor (1980) outlined three metaphors for computer use in education: tutor, tool, and tutee: first, tutor (by looking at the possible use of computer to support or to substitute teachers); second, tool (by using suitable editing tools to support students' autonomous learning); and last, tutee (by adopting special programming languages for the development of metacognitive skills in students' minds). The reader will easily recognize in the above metaphors many ideas belonging respectively to the behaviorist, the cognitivist, and the constructivist psycho-pedagogical paradigms.

Very soon, not only computing but all new technologies and especially the ICT entered in teaching–learning processes for the following reasons: to enhance students' results, to help students in overcoming their learning difficulties, to build more effective strategies for lifelong learning, and so on. Taylor's point of view, for example, has been recently integrated by Galliani, Costa, Amplatz, and Varisco (1999) to include the experiences involving CAI (computer assisted instruction) and CAL (computer assisted learning) tools, or to adopt the artificial intelligence viewpoint in the support to education with the development of ICAI (intelligent computer assisted instruction) and ITS (intelligent tutoring systems) systems.

With the Internet, the social effects induced from the Net on human activities entered in education and new instruments and processes for educational phenomena were proposed from scholars and scientists; the more relevant for what follows are virtual communities (Rheingold, 1994), which lead to the proposal of virtual communities of students and to e-learning; the definition of joint or collective intelligence (Lévy, 1996); the definition of connective intelligence (de Kerckhove, 1995); and the social negotiation extensions and the hypertextual and multimedial aspects of knowledge (Calvani & Rotta, 1999).

Most of the experiences involving the use of the ICT are concerned with the change in the instruments adopted in the carrying out of teaching-learning processes and in their organization; it has to be noted on another hand that ICT introduces new ways of thinking at teaching-learning phenomena. The most relevant examples on this side are augmented reality experiences and simulation with the use of virtual reality which are better described below.

Augmented reality is based on the use of a technology system that enhances one's perceptions and experiences by superimposing a layer of virtual reality over real world environments. The overlay of virtual reality provides more information on the real world and helps subjects in having a deeper and better view of phenomena. The augmented reality experiences enable contextual learning which can be applied to one's job or study.

Simulation in virtual environments let people access new environments and experiment sensations and emotions not less real than the ones they have in reality. The flight simulator, by which an airplane can be driven from everyone without any problem, is perhaps the system better representing the features of this educational method and its potentialities. In what follows, another example for the use of ICT in education is discussed and the experiences the author made with it are analyzed.

BACKGROUND

The hypothesis for the existence of a new teaching method has been deduced from the results of the experiences the author recently made in two different contexts: (a) the innovation in Latin paleography teaching during the last decade, and (b) the coordination of a master course for in-service teachers (or people temporarily in this job), where the ICT and the reform of the school system were used to plan teaching activities. In the first case, some dynamic Web sites for the management of bibliographical information were introduced in paleographic teaching and research, and students were authorized to access them and to work together with librarians, archivists, paleographers, and so forth. The observation of the students' behaviors and the scores they had at the ending examinations resulted in the following deductions:

1. The suitable use of online information systems (i.e., special Web sites) had a great part in the creation of constructivist learning environments and in helping the students to develop cognitive apprenticeship strategies (i.e., the systems helped students in improving learning and performances).
2. The careful analysis of the groups of students led to the detection of the features of communities of learners for those groups; in other words, Web technologies integrated traditional learning strategies and contributed in the creation of communities of learners where they were never observed before.
3. At last, the same results from Scardamalia and Bereiter (1996) on the impact of virtual environments and simulations on students' features and skills and the ones from Lave and Wenger (1991) on legitimate peripheral participation were observed.

As regards the communities working around the information systems, it has to be remarked that every group (i.e., the students, the scholars, and the researchers working on every project) had all the features of a community of practice (Wenger, 1998, 2004). In the case of the master course "Teacher and Tutor in the Renewed School," which is the more complex and articulated answer of the pedagogical community in the university of Cassino, Italy, to the schools' requests for in-service training courses for teachers, two information systems were used for the management of the courses:

- The first one was an e-learning platform for the management of the materials and of the discussions among students, tutors, and lecturers; otherwise stated, it was used as a content management system (CSM) and a computer supported collaborative learning system (CSCLS).
- The second one, called TETIS (Teaching Transparency Information System), implemented the practices of every day teaching as required from the reform laws and supported people attending the course in the simulation of everyday teaching experiences.

At the end of the course, a survey has been proposed to the 54 people (nearly 50% of the persons attending the course) who chose to intensively use TETIS platform for simulating everyday schoolwork. In Table 1, their synthetic answers with respect to the perception of the support that TETIS can give to teaching work is reported.

Table 1.

Support given to teaching work from TETIS	**Abs. values**		**Percentage**	
	Yes	**No**	**Yes**	**No**
Is the planning of the teaching work as supported from TETIS coherent and complete?	53	1	98,1	1,9
Is the work with the platform TETIS easy enough to manage?	51	3	94,4	5,6
Do the information in the platform completely describe teachers' work?	47	7	87,0	13,0
Do the information in the platform adequately describe students' behaviors and performances?	41	13	75,9	24,1
Do TETIS platform lead teachers to better programming their work and to obtain better results?	51	3	94,4	5,6
Do TETIS platform make easier for teachers the personalization of student's teaching–learning phenomena?	50	4	92,6	7,4

IMPLEMENTATION OF PRACTICES BY MEANS OF ICT

The implementation of practices with the ICT is, in the author's opinion, a new educational method having features very similar to other historically consolidated methods but different from them. The methods having elements in common with the new one are cognitive apprenticeship (because of its guided approach to experience) and simulation of real experiences for the proposal of a virtual context within which experiences can be carried out. The differences between the new method and the others can be summarized as follow: with respect to cognitive apprenticeship, no coach or tutor has a more relevant role when compared with other people in the context under analysis; with respect to simulation, no virtual environment physically reproducing the context where the experience is made is produced. Otherwise stated, this method is different from classical and modern educational methods and can be included among the new approaches to ICT use in education.

Briefly, the most important features of the "implementation of practices with the ICT" are:

a. The planning and carrying out of an online information system implementing the processes for the management of the information produced and/or administered by a group of persons in a given context (the use of the word "group," and not of "community," is not casual and occasional because no community is needed before the introduction of the information system).
b. The presence of different functions and tasks for the people working in that context (and on the future information system). In other words, at least two different kinds of people are needed in that context: the producers and the consumers of information. Allowed people will access special areas of the system for the management of the information they are charged with; the other people, depending on the permission they have, could only look at the produced information and will extract it for reading and copying.
c. Networking communication instruments for the persons working on the information system will be made available in that context (especially the producers but not only). Messaging, forums, chats, and other tools both for synchronous and asynchronous communication will be created, starting from the analysis of information and processes to make the creation of communities easier or to help managing communities.
d. Web areas for the sharing of texts, images, and other documents will be made available to groups or subgroups of people working in that context and instruments for the collaborative analysis and development of documents will be developed; in other words, suitable instruments for helping cooperative learning and enhance the collaboration within the community/ies will be delivered.

The above description statically depicts the elements and instruments of the method, but it has to be noted that the application and use of the method needs a careful description of the steps marking its running:

a. First, it has to be noted that learning organizations, communities of learners, and communities of practice are the best candidates for the use of the defined method.
b. Second, the context has to be analyzed to obtain a clear description of the data flowing among people, structures, and substructures in the context.
c. Soon after, the people operating in that context have to be interviewed on their perception of the managed data and on their flow. Otherwise stated, not only data structure and information management must become evident, but also tacit knowledge of people has to emerge. As a consequence, action-research strategies have to be used to let people have an active part in the planning of the information system together with the designers.
d. When the system will be in its first stage and ready to start, a careful test session has to be organized to let people interact with the system and among themselves; it will be possible to verify the correctness of the data and information managed and the right behavior of the system (including integrity and security) as regards stored information.

The above descriptions outline the technical features of the information system and mostly concern with its planning and creation, but tell us nothing of its evolution or of the evolution of information management processes and of the communities in that context. From experiences the author carried out emerged a clear and definite role for online information systems in the induction of modifications in the structure of the SECI model proposed by Nonaka and Takeuchi (1995). The "implementation of practices by means of ICT" appears as a new element in the cycle before socialization and after internalization:

a. Its presence induces the creation of communities of learners and of practices also where they never existed before (i.e., the communication instruments within it create a network of relations and help people in developing common instruments, identifying in a common project, etc.). The socialization of tacit knowledge is then possible only after its introduction.
b. Once the SECI cycle is completed and explicit knowledge is internalized, people operating on the information system are conscious of information management and flow within the context and develop strategies for the amelioration of their work; these strategies can be compared with the tacit knowledge to be socialized in the next step of the old SECI model. At this moment, it is important to collect all the ideas, suggestions, and elements emerging from people activities and plan an intervention on the information system by implementing the new practices within it (i.e., a new "implementation of practices with the ICT" is needed after the internalization for the success of the method).

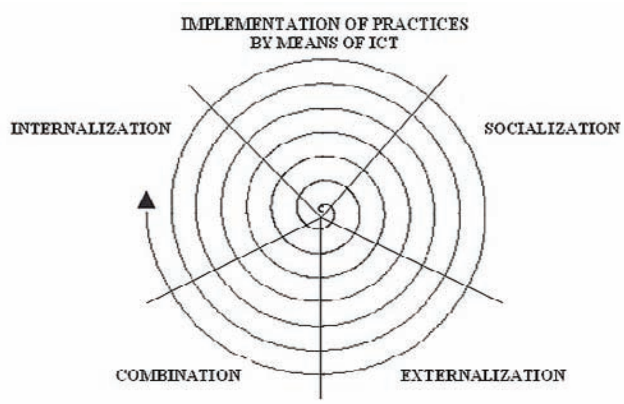
As a conclusion of the above remarks, this cycle is periodic: the "implementation of practices by means of ICT" cannot be considered an occasional event or a starting procedure; it is a new element in the model describing knowledge construction and evolution in organizations together with the well known elements of the SECI cycle. Figure 1 reports the revised model for knowledge construction and evolution after the introduction of the new element (Cartelli, 2007a).

CONCLUSION AND FUTURE TRENDS

To conclude the discussion on the features of the new teaching paradigm, a comparison among pedagogical issues, learning theories, and teaching methods is needed to see if and how they fit the paradigm. Among the different philosophical paradigms, the most relevant for the analysis of the features of the method are (Cartelli, 2007b):

- The *liberal* tradition, associated with Aristotle and Rousseau, which emphasizes the development of the intellect via a broad "well rounded" education
- *Realism* emphasizes intellectual development, reality being considered primarily in terms of empirically proven facts
- The *progressive* tradition hypothesizes the presence of strong connections between education and society, the links developed on the basis of community-relevant practical and vocational skills,
- *Behaviorism* looks at the notions of control, behavior modification, and compliance with

Figure 1. The hypothesis of new model for knowledge construction and evolution in organizations



standards
- *Humanistic* education places emphasis on freedom and autonomy, personal growth, and self-actualization
- The *radical* tradition gives to education the function of an agent for fundamental societal, cultural, political, and economic change

The implementation of practices supported by the use of MIS refers to at least two philosophical paradigms: the *progressive* tradition, for the connections between education and society it is based on, and the *behaviorism*, for the use it makes of the control and of the compliance with standards. Furthermore, *humanistic* education cannot be completely discarded due to the role played from technology in the development of subjects' autonomy, cultural growth, and self-actualization. As regards the learning strategy used from people involved in the above experiences, one can easily recognize the features of constructivism, also if both behaviorism and cognitivism cannot be excluded at all; it cannot be disregarded in fact the control action the information system has on the subjects and the connection that human memory has with storing and retrieving systems. Furthermore, the ideas from interactive constructivism, social and situated constructivism, and cultural constructivism all intervene in determining the construction of new knowledge.

It is in the author's hope that the method cana be extended to other situations and contexts so that more concreteness to its proposal will be given and the method will be better defined and specified. It is perhaps too early to say if the new method will have the success of augmented reality and simulation in virtual environments and if all together will be the new frontier for ICT use in education. It can be kept for sure that the new system is more centered on people working with information systems than on the increment of data production from real contexts or on the modeling of reality to let people learn and/or train.

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KEY TERMS

Collective Intelligence: The human intelligence emerging from cooperation among subjects; it manifests like the intelligence of a single mind (i.e., the intelligence of the whole population in a community). It appears in a wide variety of forms of consensus in decision making.

Computer Assisted Instruction (CAI): The teaching process in which a computer is used for educational purposes with students or more generally in lifelong learning. It can be used to directly propose contents on given topics or to present drills, practice exercises, and tutorial sequences to the students.

Computer Assisted Learning (CAL): The use of instructional tools presented and managed by a computer. Instructional computers either present information or fill a tutorial role, testing the student for comprehension, giving the student the feedback for overcoming difficulties, guiding the student in recovery actions when errors and/or mistakes appear.

Computer Supported Collaborative Learning System: The instruments and the strategies engaging students in common tasks such that each subject depends on and is accountable to each other. The instruments supporting the collaboration are both hardware (LAN, Internet, etc.) and software (e-learning platform, software for synchronous and asynchronous communication, etc.). The learning activities are usually coordinated from teachers and tutors.

Content Management System (CMS): A software system devoted to the management of teaching materials. Lecturers' presentations, texts, images, and every kind of teaching document is made available to the students attending a given course by identification of a code and password.

Connective Intelligence: The intelligence manifested from people when staying connected on the Internet (i.e., a social network). For its feature of being a personal quality of the subjects and for some practical aspects, like the presence of a connecting medium and the need of being connected, it is different from collective intelligence.

Virtual Learning Environment (VLE): The environment created by a software system designed to help teachers in facilitating the management of educational activities for their students, especially by helping teachers in administrating their courses. The system can, among other things, monitor both teachers' and learners' activities.

Inference Tree Use to Design Arguments in Expository Reports

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INTRODUCTION

When they write essays, many students merely attempt 'to fill pages with material gathered from sources' (Erion, 2000). Consequently, they produce inane arguments of the form:

Adams said this, Brown said that, Cohen said the other, etc.

Conclusion: much has been written about this topic.

This is unacceptable both in academic ICT courses and subsequently in the ICT profession. In academe, a written argument should 'make a leap from the raw materials of the library to an informed opinion' (Fasel, 1963). In the profession, a written argument should similarly make a leap from a present state of affairs to a desired future state. So in both situations, writers should be able to devise a report that contains an argument from available facts towards an intelligent conclusion. This kind of report is called an 'expository report' (Trimble, 1975), or an 'argumentative report' (Dykeman, 1974).

In order to write such reports successfully, ICT writers can get a great deal of useful advice from textbooks of Writing for ICT (e.g., Warner, 1996; Zobel, 1997), as well as textbooks of technical writing (e.g., Andrews & Blickle, 1982; Pauley & Riordan, 1993), business writing (e.g., Ruch & Crawford, 1988), nonfiction (e.g., Fryxell, 1996; Zinsser, 1990), and even prose style (e.g., Strunk & White, 1979; Trimble, 1975). There they will find a variety of methods, such as structuring sentences and paragraphs, introducing a report and ending it, outlining a report and editing it, and so forth, which are useful for writing reports of any kind: narrative, descriptive, imperative, or expository/argumentative. However, they will find little or no advice on devising the argument in an expository/argumentative type of report.

Yet, ICT writers need not despair. Specific argumentation aids are actually available right under their noses in ICT textbooks of artificial intelligence (e.g., Giarratano & Riley, 1989; Turban, 1992). There they will find a tool called the *inference tree*, and two associated techniques called *forward chaining* (FC) and *backward chaining* (BC). Although these three aids were originally intended for the purpose of devising expert systems and related computer applications, writers can easily adapt them for the purpose of devising expository/argumentative reports. The *inference tree* can be used to outline the argumentation product; the *chaining* techniques can be used to facilitate the argumentation process.

BACKGROUND

In such reports, the argument is situated in the paragraphs beyond the introduction. Each of those paragraphs consists of a single *core idea* supported by several *peripheral ideas* (Andrews & Blickle, 1982). For example, the following paragraph has a single core idea (in italics), which is supported by four peripheral ideas.

This system has no validation. We examined the system specification, looking for all programs that capture data from human sources. Then, we examined the if-then commands in each program, but found that none of the if's detect data errors, and none of the then's produce error messages.

The argument involves *inferences* between core ideas. Each inference inputs the core ideas of one or more previous paragraphs, and outputs the core idea of a subsequent paragraph. Example:

This system has no validation

If it has no validation, then it captures bad data
So it captures bad data.

Table 1. An argument

This system has no validation.
If no validation, then it captures bad data.
So it has bad data.
If bad data, then it produces bad information.
So it has bad information.
If bad information, then users make bad decisions.
So users make bad decisions.
If bad decisions, then we are blamed.
Therefore we are blamed.

The argument usually contains *many* inferences (Fisher, 1988; Hamblin, 1970; Mende, 2005a, 2005b; Parsons, 1996). For example, Table 1 outlines the argument in a simple report about validation (omitting all peripherals, and indicating the inferences with the keywords **so** and **therefore**).

An inference tree is a diagrammatic outline of an argument (Mende, 2005a; Turban, 1992). For example, Figure 1 is the inference tree of the argument outline in Table 1.

An inference tree omits all the peripheral details that appear in the written report. Boxes represent core ideas only, and arrows represent inferential connections between those core ideas. The boxes are arranged in three columns.

Premises: core ideas that are not inferred from other core ideas.

Intermediates: inferred from other cores, and other cores are inferred from them.

Conclusion: inferred from other cores, but no other cores are inferred from it.

This kind of diagram has been mentioned by several authors on formal logic (Carney & Scheer, 1980; Copi & Cohen, 1994; Hurley, 2000; Kelley, 1990) and on informal logic (Copi & Burgess-Jackson, 1996; Freeman, 1993; Grennan, 1997; Kneupper, 1978; Little, Groarke, & Tindale, 1989; Reed & Rowe, 2005; Scriven, 1976; Toulmin, 1969; Twardy, 2004).

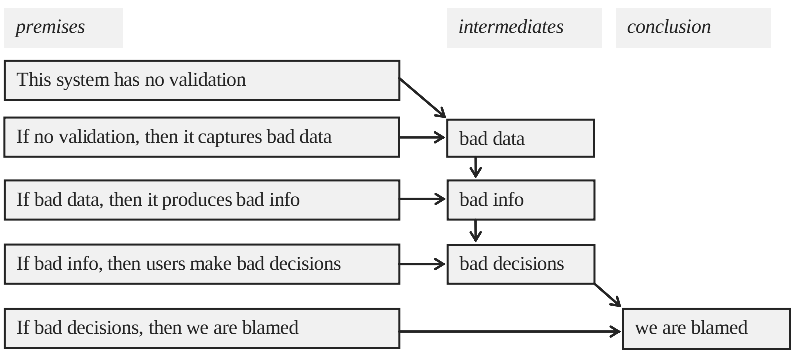
USING INFERENCE TREES

Yet the previous authors have neglected three important questions: (1) How should writers proceed to draw an inference tree? (2) How should they use the tree after drawing it? (3) How should they deal with the tree of a large argument? These questions need to be answered before the inference tree can be used as a practical aid in devising an argument.

Drawing an Inference Tree

Writers can draw an inference tree by emulating the forward and backward chaining algorithms of an expert system. These algorithms easily enable a computer to draw Figure 1. Suppose the computer's knowledge base contains five premises: one is the fact 'no validation,' and the others are simple if-then rules:

Figure 1. Inference tree of Table 1



if no validation, then bad data
if bad data, then bad info
if bad info, then bad decisions
if bad decisions, then we are blamed.

Forward chaining lets the computer generate inferences from premises through intermediates to the conclusion. The computer inputs the fact 'no validation,' and then repeatedly matches facts with rules to get new facts, until a conclusion emerges.

'no validation' + 'if no validation, then bad data' → 'bad data'
'bad data' + 'if bad data, then bad info' → 'bad info'
'bad info' + 'if bad info, then bad decisions' → 'bad decisions'
'bad decisions' + 'if bad decisions, then we are blamed' → 'we are blamed'.

Alternatively, *backward chaining* lets the computer generate inferences from a hypothesis of the conclusion through intermediates to premises. The computer selects the hypothesis 'we are blamed' and then repeatedly matches hypotheses with rules to get new hypotheses, until it reaches facts:

'we are blamed' ← 'if bad decisions, then we are blamed' + 'bad decisions'
'bad decisions' ← 'if bad info,' then bad decisions' + 'bad info'
'bad info' ← 'if bad data, then bad info' + 'bad data'
'bad data' ← 'if no validation, then bad data' + 'no validation'
'no validation' confirms the initial hypothesis 'we are blamed.'

Conceptually, the forward and backward chaining algorithms are quite simple. They can easily be converted into human procedures, either separately or jointly (recommended by Croy, 2000). Then, writers can use them as techniques for designing the argument of Figure 1, as well as many other simple arguments premised on if-then rules. Writers can even extend the chaining techniques to design the inference trees of more complicated arguments, which are premised on knowledge that is not expressed in the form of if-then rules. For example, FC and BC have been used to generate Figure 2, which outlines an argument about the feedback control cycle (FCC).

Figure 2. Argument about the feedback control cycle

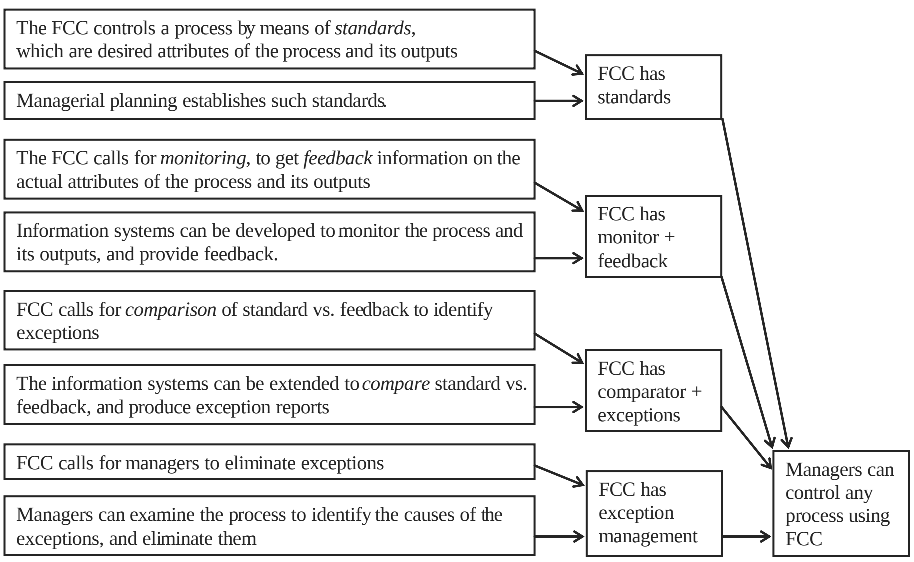
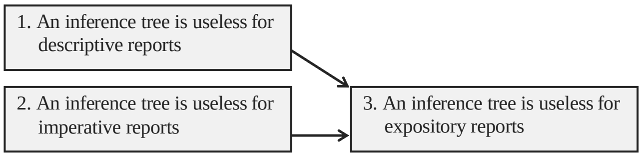


Figure 3.



Using an Inference Tree

An inference tree has at least two uses. First, writers can use it in the same way as the traditional essay *outline*, as a design aid for creating a skeleton of core ideas to which they subsequently attach flesh of peripheral ideas. Second, writers can use an inference tree in the same way as a program flowchart or structure chart, as a means of detecting and eliminating major logic errors before attaching minor peripherals. When writers devise arguments, they commit many errors of illogical reasoning (Engel, 1999; Hamblin, 1970; Johnson, 2002; Miles, 1951; Thouless, 1953). Those errors are difficult to detect in a written report, where they are obscured by the many peripherals that surround the core ideas, but they are easy to detect in an inference tree, which omits peripherals, and explicitly connects core ideas, so that writers can focus their attention on core ideas and inferential connections between them.

An inference tree helps detect two broad classes of reasoning errors. The first class consists of reasoning *effectiveness* errors: these errors raise doubts in readers' minds when they follow the chain of reasoning from premises through intermediates to the conclusion. One effectiveness error is *illusory relevance*. At first glance, the inference inputs appear to be relevant to the output, but on careful comparison, they turn out to be not really relevant. For example, Figure 3 focuses on part of an inference tree where the inputs are not really relevant to the output.

In a report, this error might not be easy to see because the core ideas of paragraphs 1 and 2 are interspersed with many peripherals (such as examples of descriptive and imperative reports where inference trees are useless). But the error is easy to see in an inference tree, where the core ideas are placed in close juxtaposition, so that they are directly comparable.

A second effectiveness error is *missing the point*. An entire argument may miss the point if its premises and intermediates do not imply the stated conclusion, but instead imply a different conclusion. For example, in Figure 4, the premises and intermediates 1-6 refer to expert systems, so that the conclusion 7 should also refer to expert systems, but actually refers to something entirely different.

This error is not easy to see in a written report, where the core ideas 3 and 6 are obscured by peripherals; but it is easy to see in the inference tree, where 3 and 6 are close to the conclusion.

A third reasoning effectiveness error is *insufficient reasons*. Most inferences require two or more inputs: so if an inference has only one input, it may have insufficient reasons to justify the output. For example, Figure 5 focuses on one such inference, which omits the input of Miller's 7±2 limit on the capacity of the human short-term memory.

Inference trees also help writers detect another four reasoning effectiveness errors.

Irrelevance: an inference may insinuate a new idea into the output, which is not explicitly present in the inputs, nor is implied by them. This kind of error can be detected by comparing the concepts within the inference inputs and output.

Begging the question: an inference merely translates the input into a synonymous output. This kind of error can be detected by noticing that the inference has only one input.

Circular reasoning: a series of inferences links an input to a synonymous output. This kind of error can be detected by noticing that the inference tree has a cycle.

Hasty generalization: an inference induces a generalization from a sample of existing facts, but the sample is very small, or specifically selected for similarity, or atypical of the population. This kind of error can be detected by noticing that the inputs are similar facts, but few in number.

The second broad class of reasoning errors consists of reasoning *efficiency* errors, which cause readers to waste time when they try to understand the chain of reasoning from premises through intermediates to the conclusion. One efficiency error is *overloaded inference*. It involves an unnecessarily difficult inferential

Figure 4. Missing the point

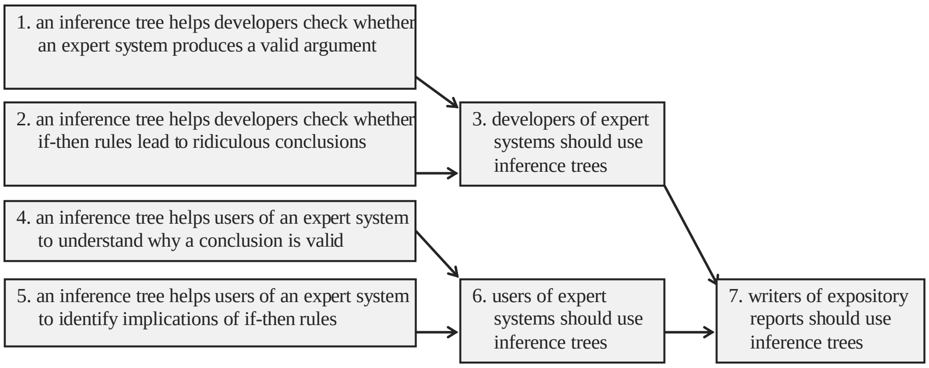
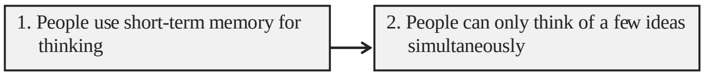


Figure 5. Insufficient reasons



leap from many inputs to the output and could be replaced with a series of smaller, simpler inferences that are easier to understand. For example, the inference tree of Figure 6 has a hugely overloaded inference from premises 1-6 to conclusion 7.

This error could escape notice in a written report, where core ideas are interspersed with many peripheral ideas; but it would be glaringly obvious in the inference tree. A second efficiency error is *superfluous inputs*. When an inference has several inputs, all of them might seem necessary to justify the output, but on closer inspection, only some may be found to be necessary, whereas others are unnecessary. For example, Figure 7 focuses on an inference that has two superfluous inputs (3 and 4).

A third efficiency error is *redundancy*. A premise of argument is redundant if no inference connects it to an intermediate or to the conclusion; similarly an intermediate is redundant if no inference connects it to other intermediates or to the conclusion (so that the entire sub-argument behind that intermediate is redundant). For example, the inference tree in Figure 8 contains two redundant premises (1 and 5) and a redundant sub-argument (2-4).

Inference trees also enable writers to detect another four reasoning efficiency errors:

- **Omitted inference:** The inference output is not stated explicitly. This error can be detected by noticing that adjacent boxes have no emergent inference arrows.
- **Belated inference:** Inputs the core idea of a prior paragraph that is unnecessarily far removed from the paragraphs that contain the output. This error can be detected by noticing long inference arrows that could be shortened.
- **Premature inference:** Instead of an input appearing far before the output, it is placed far after. This error can again be detected by noticing long inference arrows that could be shortened.
- **Incoherence:** Paragraphs with similar core ideas are grouped together in the same section of an argument; yet inferences connect those core ideas not to one another but to core ideas of paragraphs in other sections. This error can be detected by noticing that several arrows cross unnecessarily.
- **Inconclusive argument:** Either there is no conclusion whatsoever, or an inane conclusion is attached as an afterthought, for example, 'much has been written about this topic.'

Figure 6. Overloaded inference

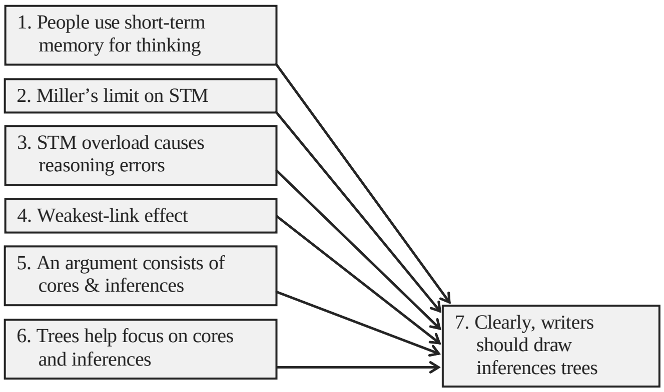
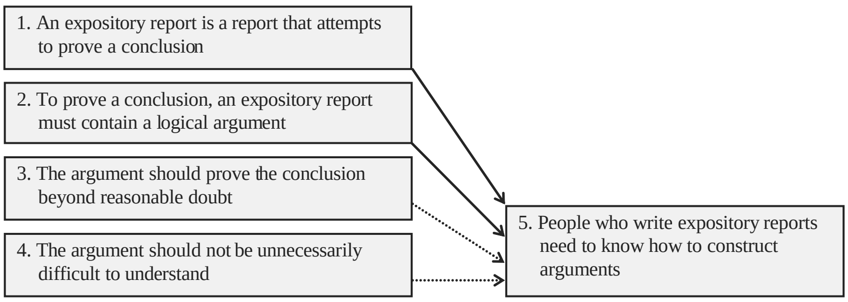


Figure 7. Superfluous inputs



LARGE ARGUMENTS

Many reports contain an argument that is much more complex than the above, and the inference tree spreads over several A4 pages. Such a tree would be difficult to draw and to check if the writer continually has to flip back and forth among the different pages. This difficulty can be eliminated by applying the principle of *modularity* (Mende, 2005b). Simply decompose the argument into several self-contained sub-arguments: a concluding sub-argument (which will appear at the end of the report), and several supporting sub-arguments (which will appear in the middle of the report). Low-level inference trees then outline supporting sub-arguments to intermediate conclusions A, B, C, and so forth, and a high-level inference tree outlines the concluding sub-argument from A, B, C, and so on, to a final conclusion Z. Figure 9 sketches the arrangement.

CONCLUSION

An inference tree is a diagrammatic outline of an argument that spreads over many paragraphs in a written report. Boxes represent the core ideas of the paragraphs, and arrows represent inferences connecting the core ideas.

Premises are core ideas that are not inferred from other core ideas.

Intermediates are inferred from other cores, and other cores are inferred from them.

The *conclusion* is inferred from other cores, but no other cores are inferred from it.

Writers can draw an inference tree using the techniques of forward or backward chaining. With forward chaining, they first match related premises to get intermediates; then they match premises with related intermediates to get further intermediates until

Figure 8. Redundancies

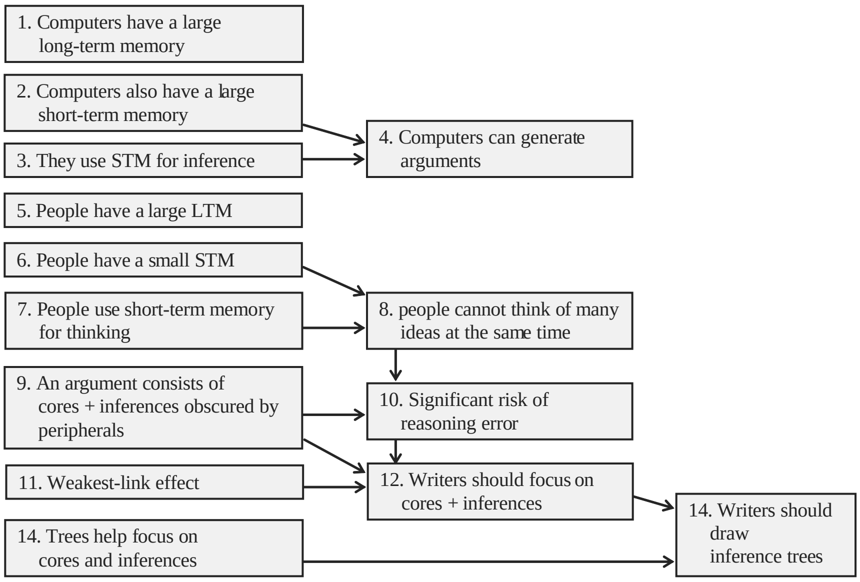
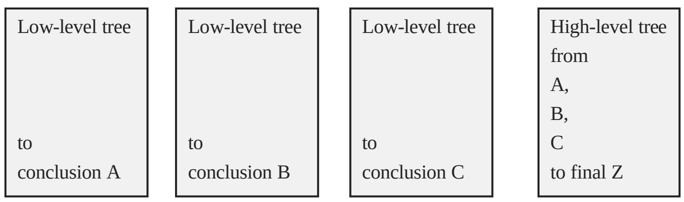


Figure 9. Modular hierarchy of inference trees



a conclusion emerges. Alternatively, with backward chaining, they start with a hypothesis of the desired conclusion, match it with related premise to get a new hypothesis, then match it with other premises to get further hypotheses, until they reach premises. When all hypotheses match premises, the concluding hypothesis is confirmed.

Writers can readily use an inference tree to detect reasoning errors that would otherwise be difficult to find in a written report, where core ideas are obscured by a multitude of peripheral ideas. The tree reveals several kinds of *effectiveness* errors that raise doubts in readers' minds: illusory relevance, irrelevance, insufficient reasons, hasty generalization, begging the question, circular reasoning, and missing the point. An inference tree also reveals several kinds of *efficiency* errors that waste readers' time: overloaded inference, superfluous inputs, omitted inference, belated inference, premature inference, incoherence, redundancy, and inconclusive argument.

If an argument is very large, writers can outline it by means of a modular inference tree. This consists of a high-level concluding tree together with several low-level supporting trees. The low-level trees are self-contained and can be drawn (and checked) independently. Thus, inference trees are not difficult to draw and are useful both for outlining an argument and for debugging the outline before detailed writing. Therefore, if writers need to devise reports that contain arguments towards intelligent conclusions, they should use inference trees.

FUTURE TRENDS

Work in progress suggests that inference trees could have at least three uses beyond the outlining of student essays and professional reports. First, inference trees could help instructors introduce *reasoning* into ICT courses. This is important because ICT textbooks tend to be inference-free, so that students see very few exemplars of reasoning. Second, inference trees could help ICT researchers introduce reasoning into empirical research proposals, dissertations, and papers. Trees could be used to outline arguments that identify research questions, justify appropriate methods of answering the questions, show that the research results answer the questions, and derive implications. Third, inference trees could be useful in academic knowledge construction. In particular, they could help ICT researchers develop explanatory theories of ICT. An explanatory theory consists of deductive arguments from hypothetical axioms to existing empirical generalizations, and trees could help outline and check such arguments. Furthermore, several software packages are being developed to help people draw inference trees (Harrell, 2005; Kirschner, Shum, & Carr, 2003; Rowe, Macagno, Reed, & Walton, 2006; Van Heuveln, 2004). Inference trees could be a very useful tool in the field of ICT.

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KEY TERMS

Argument: A series of inferences from premises through intermediates to a conclusion. Premises are core ideas that are not inferred from other core ideas; intermediates are inferred from other cores, and other cores are inferred from them; the conclusion is inferred from other cores, but no other cores are inferred from it.

Backward Chaining: A technique of generating inferences from a hypothesis of the conclusion, through intermediates, to premises. You start with the concluding hypothesis, match it with related premises to get a new hypothesis, then match it with further premises to get another hypothesis, and so on, until the last hypothesis is confirmed. Then, the concluding hypothesis is also confirmed.

Forward Chaining: A technique of generating inferences from premises through intermediates to a conclusion. You start by matching related premises to get intermediates; then match premises with related intermediates to get further intermediates, and so on, until a conclusion emerges.

Inference: An elementary reasoning step that inputs previous core ideas of an argument and outputs a subsequent core idea.

Inference Tree: A diagrammatic outline of an argument. Boxes represent core ideas of paragraphs, and arrows represent inferential connections between core ideas. The boxes are arranged in three columns: premises, intermediates, and conclusion.

Modular Inference Tree: A high-level concluding tree together with several low-level supporting trees. The low-level trees have little or no connection to one another and can be drawn and checked independently, each on a separate page.

Reasoning Effectiveness Error: Raises doubts in readers' minds when they try to understand an argument. A typical example is *illusory relevance*, where inference inputs appear to be relevant to an output, but are really not. Another example is *irrelevance*, where an inference insinuates a new idea into the output, which idea is not present in the inputs.

Reasoning Efficiency Error: Wastes readers time when they try to understand an argument. A common example is *inconclusive argument*, which leads either to no conclusion at all or to an inane afterthought such as “much has been written about this topic.” Another example is *overloaded inference*, which could be divided into smaller, simpler inferences.

I

Information Communication Technology Tools for Software Review and Verification

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INTRODUCTION

While information communication technology (ICT) can be considered a well-established discipline, software development projects are still prone to failure. Even if a software project is not classified as a failure, the general level of software quality leaves room for much improvement. It has been suggested that one of the most prevalent and costly mistakes made in software projects today is deferring the activity of detecting and correcting software problems until the end of the project. Hence, the cost of rework in the later stages of a project can be greater than 100 times the project costs. About 80% of avoidable rework comes from 20% of defects. As a result, techniques such as software review for improving software quality are important.

Software review (inspection/verification) was originally introduced by Fagan (1976). The review process essentially includes six major steps:

1. **Planning:** Organize and prepare the software review, typically for preparing the review materials and review procedure, forming review team and scheduling review meeting, selecting review participants, and assigning roles.
2. **Overview:** Author explains overall scope and the purpose of the review.
3. **Individual preparation:** Individual reviewers analyze and review the software artefact.
4. **Group review meeting:** Find errors, sometimes also called "logging meeting." Review teams correct and the reader summarizes the work.
5. **Rework:** Defect correction, which involves the author in resolving problems by reviewing, revising, and correcting the identified defect or by decreasing the existence of errors of the software artefact.
6. **Follow-up:** Validate the correction quality and decide if re-inspection is required

Since Fagan (1976) introduced software review and verification as an important technique to assure the quality of software projects, researchers have investigated ways to improve software review performance. It has been suggested that ICT software review tools are one of the important elements to the support software review process. This article overviews ICT tools to assist software review and verification during this software review process. The overall objective of this article is to identify various ICT tools that support software review and verification. This includes a discussion of the importance of software quality and identifies ICT tools for effective software reviews and verification.

ICT TOOLS FOR SOFTWARE REVIEW AND VERIFICATION

Intelligent Code Inspection in a C Language Environment (ICICLE)

The ICICLE (Intelligent Code Inspection in a C Language Environment) is the first published software review tool, which was developed at Bellcore (Brothers, Sembugamoorthy, & Muller, 1990). The ICICLE tool is designed to support code review and assists reviewers in both individual preparation and group meetings. ICICLE provides a synchronous communication support to group meetings. It has been argued that traditional code review meeting is manually documented (i.e., using paper and pen to record defects detected). This documentation procedure is very time consuming, tedious, and could be inconsistent recording (Brothers et al., 1990). One of the aims of this tool helps software reviewers to find obvious defects. Brothers and his team (1990) suggested that ICICLE provide several benefits to code review:

- To detect routine sorts of errors, with the goal of freeing the code inspector (reviewer) to concentrate on verifying the correct implementation of requirement, specifications, and designs.

- To offer various forms of knowledge about the code being inspected (reviewed), including domain and environment knowledge, and information from various forms of analysis such as cross-referencing.
- To allow code inspectors (reviewers) to easily traverse source code in a windowed environment instead of riffling through hard copy from many different files.
- To render the code inspection (review) meeting paperless through a shared window interface which enables the code inspectors (reviewers) to fulfill their roles electronically.

The ICICLE tool consists of two phases in the review process: the individual review and group review meeting. The group review meeting takes in the same location/venue, usually a reviewers' seat at nearby computers. An individual reviewer allows entering comments on each line of code. According to MacDonald, Miller, Brooks, Roper, and Wood (1995), the researcher found that "the computer supported meeting format appeared to cause substantial changes in the dynamics of the code inspection (review) meeting." In other words, the procedures of the code review meeting using ICICLE can enable roles during the group meeting process (Brothers et al., 1990). For example, the additional duty of a moderator is to record statistics relating to coding defects discovered during code review. The reader can direct the attention of the other reviewers to areas of interest in the source code. The scribe's records must be agreed on by the review team. The author should present in the code review meeting and answer the reviewers' question. Any additional reviewers can participate and share meeting discussions.

Scrutiny

Scrutiny is an online collaborative software review tool, which was developed at Bull HN Information Systems in conjunction with the University of Illinois (Gintell, Houde, & Mckenney, 1993). It is a synchronous meeting review tool. It is one of the early comprehensive collaborative process software review tools (MacDonald et al., 1995). Scrutiny currently supports text documents only.

Scrutiny can be used in the formal review process, and it supports multi-users review but does not support for rules and checklists. It provides a "petri-net based process modeling language" that allows the system to implement alternative software review methods, such as a "shared preparation" phase in which reviewers have access to each other's preliminary findings (Gintell et al., 1993; MacDonald et al., 1995). However, in comparison with the ICICLE, the Scrutiny usage can depart radically from manual software review processes, such as geographically distributed software reviews (MacDonald et al., 1995).

Collaborate Software Inspection (CSI)

Collaborate software inspection (CSI) was built and used in a case study to compare online distributed computer-mediated software review meetings vs. face-to-face software review meetings at the University of Minnesota (Mashayekhi, Feulner, & Riedl, 1994). As with other software review tools, the CSI provides the similar process characteristics of Humphrey's software review method with hypertext capability. CSI is developed for group review meetings in the (1) same time and place, (2) same time and place, (3) same time and different place, and (4) different time and same place. CSI supports both asynchronous and synchronous activities that include materials distribution, individual preparation/individual review, group review meeting, recording, and reporting (Mashayekhi et al., 1994).

InspeQ

InspeQ was developed to support the phased software review process (Knight & Myers, 1993). The InspeQ was executed on "Sun 3, Sun 4, and IBM RS/6000 computers running various forms of Unix and the X-window display system and the OSF/Motif widget set" (Knight & Myers, 1993). Although the InspeQ achieves the goals of efficiency and rigor in the phased review process, it is not viewed as essential to the "phased inspection" method (MacDonald et al., 1995). Similar to other software review tools, InspeQ provides numbers of facilities to support software review process. These include work product display (views the documents), checklist display (allows the status of each checklist to be displayed and modified), standard display (review rational and a detailed descriptions), highlight display (helps locating particular aspects of the documents), and comments display (comments on the documents) (Knight & Myers, 1993).

CSRS

CSRS is developed to support computer-mediated communication formal software review process (Johnson, 1994). The CSRS is heavily used in academic research and laboratory experiments studies. The goals of CSRS is to reduce the human effort in review process by conducting software review incrementally during the development and provide online capabilities to collect metrics (Stein, Riedl, Harner, & Mashayekhi, 1997). The CSRS is similar to Scrutiny; it provides an internal process modeling mechanism to support a variety of review methods. CSRS's primary method is FTArm, which "is unique among methods by being designed explicitly to support properties of computer-mediated communication and review" (Johnson, 1994). CSRS automatically collects data (e.g., number of defects/issues found, comments made, time spent on software review, starting time, finishing time, event logs, etc.). Another feature of CSRS is that it supports a variety of software review processes and handles several types of documents and languages.

Requirement Traceability Tool (RADIX)

Requirement traceability refers to the "ability to describe and follow the life of a requirement, in both a forwards and backward direction" (Gotel & Finkelstein, 1994). The requirement traceability tool (RADIX) is designed for verifying software requirements (Yu, 1994; Yu, Smith, & Huang, 1990). A requirement tracing method is a systematic method to assist 5ESS Switch scientist and engineers to deliver quality software (Yu, 1994).

Asynchronous Inspector of Software Artefacts (AISA)

Asynchronous Inspector of Software Artefacts (AISA) was the early Web-based software review tool (Stein et al., 1997). AISA supports asynchronous and distribution software review as well as reviewing both textual and graphical documents (e.g., entity-relationship diagram or class diagram) (Stein et al., 1997). The AISA Web-based tools can be built using existing structures and were reasonably easy to develop.

Web Inspection Prototype (WiP)

Web inspection prototype (WiP) is another Web-based tool, which provides a set of functions for distributing the requirement documents to be reviewed (Harjumaa & Tervonen, 1998). The WiP is developed to support distributed software review processes. It utilizes the WWW to distribute the review document, tailors the software review process model according to the development environment, can assign roles, adds or removes a checklist, allows reviewers to add, modify, and remove comments, has searching, cross-referencing, e-mail notification, combining comments/ annotations using hypertext and reporting capabilities, and generates metrics and statistics summary (Harjumaa & Tervonen, 1998).

InspectA

InspectA is a completed automation tool, which allows the whole software review process to be automated (Murphy & Miller, 1997) from planing, such as selecting a moderator and communications between software review team, through follow-up stage, where the moderator verified and finalized that all the defects raised during the software review have been resolved.

InspectA is an e-mail-based and asynchronous tool for software review (Murphy, Ferguson, & Miller, 1999). The tool is not based on the World Wide Web approach (all reviewers can view other individual reviewer comments). The argument is when reviewers can view other reviewers members defect lists during the individual preparation that they may discourage (Murphy et al., 1999). Another reason is that reviewers may focus or discuss other reviewers' comments rather than focus their own individual reviews (Murphy et al., 1999). Miller and their team believed that e-mail-based tools provide a number of advantages. These include (Stein et al., 1997, p. 108):

- **Sharing information:** Allow exchange and sharing information via e-mail tool
- **Threads of discussion:** Allow individual reviewers to contribute and free feel to comments during the individual preparation
- **Visual cues:** Easy to format in the document such as bold or italics
- **Train of thought:** Offer other reviewers to response and reply

- **Reaching a consensus:** Voting can be sent via e-mail tool
- **Coordination:** Moderator can easily send information to all reviewers
- **History:** Allow reviewers to keep a record of their comments

HyperCode

HyperCode is another one of the earliest Web-based software review tools (Perpich, Perry, Porter, Votta, & Wade, 1997). It uses the common gateway interface (CGI), and the HyperCode system allows software reviewers using WWW browsers for software review (Perpich et al., 1997). It is used for code review and very similar to the WiP. Reviewers can comment on the Web, and material is delivered via the Web (Perpich et al., 1997). The process contains only asynchronous phases, and other reviewers are able to see the comments, so there is no software review meeting required when in HyperCode (Perpich et al., 1997). After individual review, the results are collated together into a report containing links from the original material to the comments (Perpich et al., 1997).

Perry and his team (Perry, Porter, Wade, Votta, & Perpich, 2002) suggested that there are four primary differences between paper-based and HyperCode software review processes. First, HyperCode provides an automated approach to the support software review process; this can reduce time and amount of review effort. Second, notification between software review team can be a useful e-mail tool. Third, all comments or annotations are visible to all participated software reviewers in the whole review process. Fourth, there is no meeting requirement needed in the HyperCode process. In other words, the review discussion is asynchronous communication.

ASYNCHRONOUS/SYNCHRONOUS SOFTWARE INSPECTION SUPPORT TOOL (ASSIST)

Asynchronous/Synchronous Software Inspection Support Tool (ASSIST) is built to provide both individual and group software review (MacDonald et al., 1995). It can perform both synchronously or asynchronously with either different place or same place meeting. It uses a costumed designed modeling language, the Review Process Definition Language (RPDL) and a flexible document type system to allow support of any software review process (MacDonald & Miller, 1999). ASSIST is a client/server architecture, where the server is a central database to store documents and data. Table 1 shows details of four features of the ASSIST tool.

Fine-Grained Software Inspection Tool/ CodeSurfer

The fine-grained software review tool is designed for "exposing the results of sophisticated whole-program static analysis" (Anderson, Reps, & Teitelbaum, 2003) to the software review. This is also known as CodeSurfer. The idea was originally developed from the "dependence graphs" which applications activities include parallelization (Burke & Cytron, 1986), optimization (Ferrante, Ottenstein, & Warren, 1987), program testing (Bates & Horwitz, 1993), and software assurance (Horwitz & Reps, 1992). A description of how this tool work is summarized in the following section.

CORD

The CORD is developed for increasing the consistency between requirements and a detailed design (Chechik & Gannon, 2001). The CORD creates a "finite state abstraction" of a detailed design and checks it against a set of properties automatically generated from the requirements (Anderson et al., 2003). Its features are similar to other static analysis tools such as CodeSuper. The aim of CORD is to "simplify the verification of properties of program; this system abstract the forms of their formal specification notations or create abstract models from program that could be analysed with state-exploration" (Chechik & Gannon, 2001, p. 669).

Agent-Based Software Tool

Agent-based software tool in code review is designed by Chan (2001). Chan (2001) recently proposed the agent-based software tool that can help reduce the cost and increase the number of defects detected in the software review process. The main focus of the intelligent agent software tool (Chan, 2001) is to:

- Automate as much of the paper work and administrative tasks as possible

- Enable the inspection (review) to perform inspection (review) according to their schedules. This aims to reduce the inspection (review) interval, and thus reducing the turn around time for obtaining inspection (review) results
- Provide as much assistance to the inspector (reviewer) as possible during preparation
- Maximize the number of major faults found while keeping the time costs of the process low

INTERNET-BASED INSPECTION SYSTEM (IBIS)

Internet-based inspection system (IBIS) is developed to support geographically distributed software review (Lanubile & Mallardo, 2002). IBIS was originally designed by Cavivano, Lanubile, and Visaggio (2001). This tool is another Web-based application which is "based on a lightweight architecture to achieve the maximum of simplicity of use and deployment" (Lanubile & Mallardo, 2002). The IBIS can support Fagan's Software Review Process. There are a several advantages of deploying IBIS (Lanubile & Mallardo, 2002):

- IBIS is Web-based software review tool; it allows reviewers access from their desktop. This could improve the chance of reviewers participating in software review
- It allows the software review to be performed in different places, even in different countries
- Allow different experts participate in the software review process. Those experts could from outside the organization or different department.

VisionQuest

VisionQuest aims to support the experimentation formal anonymity technical review (Vitharana & Ramaurthy, 2003). The advantages of anonymity in group collaboration are (Er & Ng, 1995):

- Each reviewers has equal weight
- Avoid the dominance group or status effect during the review process
- Since the comments are made by an anonymous person, criticisms are the issues rather than people
- Voting is anonymous; the final decision is more likely to be objective and based on merit

FUTURE

A number of computer support tools have been developed to support the software review meeting process. Many tools provide documentation facilities that allow software review documents to be shared across networks, browsed online, and edited by reviewers. The current trend of software review is for using software review tools to the support software review process. Past research has shown a spectrum of advantages of using software review tools supporting technical review. First, a computer-support tools review environment can reduce paper work and clerical costs, decrease error rates of recording review meeting and comments, and allow computerised data collection and data analysis. Software review tools can integrate the review method with other components of the specific software development method such as asynchronous review and facilitating both metrics collection. Companies will adopt software review tools simply because of such potential benefits over manual software review techniques.

CONCLUSION

In summary, this article described modern software review tools and techniques and the different types of software review tools and how they work. To achieve better software review performance, it is important to understand use of inputs and the software review process.

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KEY TERMS

Asynchronous Review: The review activities can be performed at the same time. Asynchronous review must rely on the ICT tools supported.

Defects: The term "defect" is defined as any issue or problem that does not meet the requirements.

Fagan Inspection: Software review was originally proposed by Michael Fagan at IBM in the early 1970s. Fagan's software review and forms of review structures. Fagan's software review includes six-step review processes: planning, overview, preparation, group meeting, re-review, and follow up.

Information Communication Technology (ICT) Review Tools: Tools provide documentation facilities that allow software review documents to be shared across networks, browsed online, and edited by reviewers. The current trend of software review is for using software review tools to support the software review process.

Online Software Review: Online software review tools support some major functions: document support, individual preparation, and meeting support. It can meet online and share data and documents in flexible time, thus it may reduce time of review.

Software Review: Software review or inspection is one of the techniques for improving software quality. Software review is an industry-proven process for eliminating defects. It has been defined as a non-execution-based technique for scrutinizing software products for defects, deviations from development standards.

Software Verification: Aims to find and remove defects during the software development cycle.

Synchronous Review: All review activities in the synchronous software review happen in a linear fashion, and the meetings are located in same place at the same time.

Information Environments of Middle Managers in Higher Education

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INTRODUCTION

The importance of middle managers is frequently noted in the context of strategic management and other key decisions (Floyd & Wooldridge, 1996; Gold, 1998; Kettunen, 2002). The role of the middle managers can, however, be much greater because they are responsible with other creative individuals for the innovations of their subunits. They assume the responsibility for developing many information systems to serve the processes of the organisation.

There has been some criticism of the limited scope of information system innovation research (Lyytinen & Rose, 2003a, 2003b). The purpose of this article is to show that the information systems of an education institution can be classified according to the information environments (IEs) and other characteristics such as the organisational levels. The analysis reveals the creative class of a higher education institution (HEI) which assumes responsibility for developing the information systems in cooperation with the other units of the institution and networks.

The empirical case of this article illustrates the information environments and information systems of the Turku University of Applied Sciences (TUAS). It is argued that technology and behaviour are not dichotomous in an information environment; they are inseparable. The analysis helps education management to develop the institution's information systems in an innovative way.

The article is organised as follows: First, the role of middle managers is discussed in the background section of the study. Next, the concepts of IEs are introduced and information systems are analysed using the various IEs. This is the main focus of the article. Thereafter, the information environment of degree programme managers is shortly discussed. Finally, the results of the study are summarised and discussed in the concluding section.

BACKGROUND

The role of middle managers has been changing in Finland. Finnish universities of applied sciences (formerly known as polytechnics) are in an interesting phase of organisational development because a major reform of higher education took place in the 1990s. The universities of applied sciences were established by taking parts from the vocational institutions. At the same time, hundreds of separate vocational institutions merged to constitute larger multidisciplinary institutions.

The reform caused major organisational and functional changes in the education institutions. The reform produced changes in the working cultures and autonomy of the institutions and changed their patterns of management and administration. Many management tasks were transformed from the rectors of vocational institutions to the expanding middle management of the new institutions. Larger organisations demanded for more managers to take responsibility for degree programmes and also many new development functions in the institutions.

A matrix organisation is a typical model in the Finnish universities of applied sciences. Typically, the institutions have four to eight education departments (faculties) led by directors of education (deans). Each education department includes several degree programmes. The institutions have also a department of support services led by the rector and vice rectors.

The department of support services includes support service units such as international relations, library, and human resources management.

In the last decade, when the structural reform of the universities of applied sciences was introduced, a reform in their operating environment took place. New constructivist ideas about learning turned increasing attention to students and their progress. These new ideas can be called a service paradigm or a customer paradigm in Finnish vocational higher education. At the same time, there occurred a major change in the technical environment and information systems, which modified the traditional ways of learning, teaching, and management.

An important group in the organisational and functional development of institutions is that of the middle managers. The middle managers of matrix organisations in the Finnish universities of applied sciences can be classified into three main groups: degree programme managers, research and development managers, and support service managers. It is emphasised that the strategic management of these middle managers can be crucial for organisational success in an HEI. This is important, if the education and business environments of departments are distinct from each other. Especially in larger organisations, a greater degree of responsibility has been assigned to subunits.

The programme managers may typically be responsible for one large or several smaller degree programmes. The middle managers of the support services, such as the development manager, quality manager, financial manager, and manager of international relations, are responsible for a specific sector in the whole institution. Many other expert positions belong to the group of middle managers in a broad sense, even though these people do not have a manager's title. Floyd and Wooldridge (1996) point out that the roles of the middle managers are to champion innovative initiatives, facilitate adaptability to new behaviour, synthesise information within and outside the organisation, and implement strategy.

MAIN FOCUS OF THE ARTICLE

Information Environments

The information environment approach was introduced by Ståhle and is described in several articles (e.g., Ståhle & Grönroos, 2000; Ståhle & Hong, 2002; Ståhle, Ståhle, & Pöyhönen, 2003). According to the IE approach, the organisation can be described as a knowledge creating system arising as a result of interaction between individuals and groups. The characteristics of the networks define the different IEs. The know-how, relationships, information flow, and management are the dimensions to analyse the IEs. Management has a remarkable role in creating these environments.

According to this approach, there are different kinds of IEs:

- Mechanical
- Organic
- Dynamic

These environments are the results of management actions and have different kinds of know-how and knowledge structures. They have different kinds of relationships and information flows within and outside the organisation. Riihimaa (2004) emphasises that a taxonomy can be an essential element to create theory and analyse information technology.

Mechanical IEs are strictly documented and determined. The information systems in these IEs include accounting systems and the student and study registers. Typically, the input is strictly controlled, information flows one way, top-down, and the system produces certain kinds of reports. Automation is important because these information systems have been planned to increase the efficiency of routine tasks. The creative human contribution can be directed to more important functions.

Organic IEs emphasise communication and dialogue. The information systems in this environment have been designed for making course implementation plans and collecting feedback from students. The management information system based on the balanced scorecard approach also belongs to this environment (Kettunen, 2005; Kettunen & Kantola, 2005). The members of the organisation share their experience-based tacit knowledge (Kim, Chaudhury, & Rao, 2002; Nonaka & Takeuchi, 1995; Takeuchi & Nonaka, 2004), try to make it explicit, combine knowledge, and develop the internal processes. The organic IEs require development-oriented management, in which middle managers have an important role. Management includes power sharing, development of feedback systems, and fostering of efficient communication in the organisation.

Dynamic IEs aim to continuously produce innovations. The wide and fast information flow is a characteristic of this environment. Many of the innovations are based on the weak signals of the environment. Networking with other individuals and organisations requires dynamic IEs. Management is not strictly controlled because the purpose is that innovations emerge from self-organisation. The innovation process is led by the person who is best suited for the task.

Information Systems

Table 1 describes the three-dimensional IEs by the organisational levels at the TUAS. The tick “x” indicates frequent use of information systems belonging to the certain IE and organisational level. It can be seen that the mechanical information systems are mainly used by the middle managers, teachers, and other personnel. The organic information systems are used by all organisational levels. The dynamic information systems are mainly used by the middle managers and teachers.

The most valued workers are what Richard Florida (2002) calls the creative class. He argues that investment in technology and a civic culture of tolerance are the key ingredients to attracting and maintaining a local creative class. Table 1 shows that the creative class at the TUAS mainly consist of middle managers. This definition gives a only broad description and is not strictly correct because there are certainly creative people among the teachers, rectors, and other personnel.

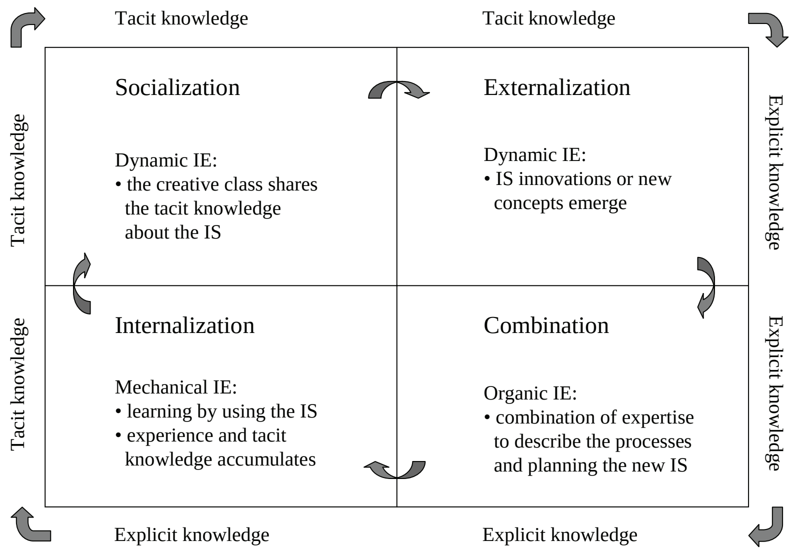
Figure 1 presents the spiral of knowledge conversion in information environments and how an information system can be developed in a learning process. The four modes of knowledge conversion were introduced by Nonaka and Takeuchi (1995): (1) from tacit knowledge to tacit knowledge, which is called socialization; (2) from tacit knowledge to explicit knowledge, or externalization; (3) from explicit knowledge to explicit knowledge, or combination; and (4) from explicit knowledge to tacit knowledge, or internalization. This model (SECI) of knowledge creations is applied in this study to the IEs and the development of new information systems.

In the socialization mode, the middle management or any other members of the creative class share experiences with the directors, teachers, and other professionals in a dynamic IE. In the externalization process, the tacit knowledge is of the creative class if transformed to explicit knowledge. In a successful case, information system innovations or new concepts emerge. The combination mode involves combining different bodies of explicit knowledge. The management information system can be a valuable tool to make new ideas and knowledge visible. The management information system also makes it possible to connect separate degree programmes and organisational units and build cross-functional teams and expertice groups. Finally in the internalization mode, the experience in using the information systems helps the users to transform the explicit knowldete into tacit knowledge.

Table 1. The three-dimensional IEs by the organisational levels

Organisational levels	Mechanical	Organic	Dynamic
Rectors		x	
Directors of education (deans)		x	
Support service managers	x	x	x
Research and development managers	x	x	x
Degree programme manager	x	x	x
Teachers	x	x	
Other personnel	x	x	

Figure 1. The spiral of knowledge conversion in information environments



FUTURE TRENDS

This section briefly analyses the IE of the degree programme manager. Several questions arise when outlining the IE needs of the degree programme of the HEI:

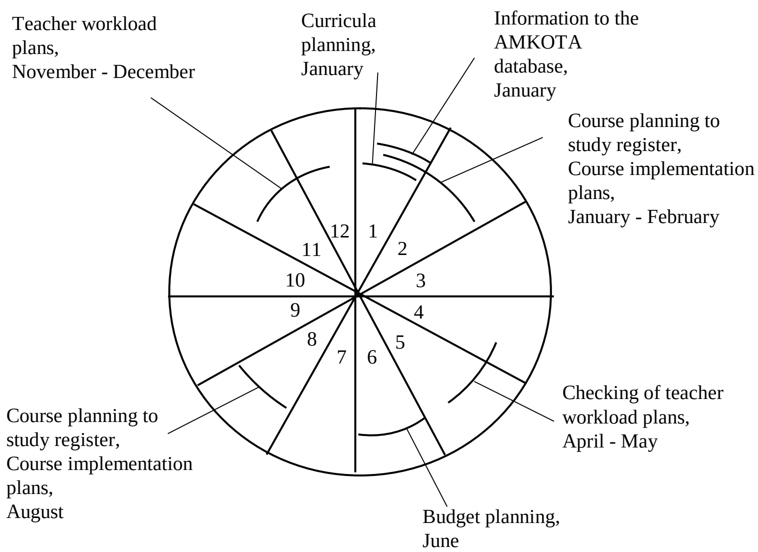
- Which environments do the degree programme managers mainly need in order to survive in the every day work of the degree programme?
- Are the environments of degree programme managers too much in the mechanical area although competitive advantage can be achieved in dynamic IEs?
- Is it the case that in matrix organisations the dynamic environments are led by the support service managers and the mechanical and organic environments are used by the degree programme managers?
- Do we need to add new interactive and open elements to the traditional information environments?

The most important information system for the vitality of the degree programme is the study management system (student and study registers) containing information on students and their studies. The next important system is the teacher workload planning system. This is used to organise the work of teachers. It is also important because the pay of the teacher depends in some cases on the number of teaching hours.

Figure 2 presents the annual use of the information systems of degree programme managers. In order to obtain a holistic picture of the information systems used by the degree programme managers, the main tasks needing information systems are presented using the year clock presentation. In the year clock, some phases must be accomplished once a year and the others more frequently. The phases can also be found on the year clocks of the previous and following years.

From the point of view of middle management, the calendar starts in January with curricula planning. The curricula are saved in a database in the TUAS intranet environment. Overlapping the curriculum planning, the data on student numbers and study performance of the previous year must be submitted to the national database of Finnish universities of applied science (AMKOTA). The collection of data is important because it is also needed in the management information system and for quality assurance. The middle managers must also produce a written evaluation of the results achieved in the previous year.

Figure 2. The annual use of the information systems of degree programme managers



After the curricula planning in January and February, the course implementation plans are on the agenda. The implementation plans must be prepared at least twice a year. The courses are first planned in the study register (Winha). Then the teachers are advised to prepare detailed course implementation plans using specific software (Totsu). The implementation plans include the anticipated time resources of students and teachers for each course in every period and the reservation of classrooms and other facilities.

The next milestone is in April and May, when the degree programme managers and teachers check and finalise the course implementation plans in the information system (Totsu). They also check the teacher workload plans using the workload information system (Tilipussi), which is linked to the human resources information system (Fortime) and the accounting information system (Web Hansa). The workload plans of tenured teachers must be checked twice a year to define the exact salary.

In June, the budget for the next year must be planned using the management information system (4T) which is linked to the accounting system. The funding from central government is primarily allocated to the costs of education in degree programmes and administration costs. The education and teacher workload plans are carefully aligned with the budget to ensure balanced economy. The external funding is allocated mainly to research, development, and continuing education. An electronic project management system (Projektori) is used for project management.

In August, the course planning and course implementation plans have a similar procedure as at the beginning of the year. The course implementation plans must be prepared for the autumn term. The degree programme managers also arrange meetings for the teachers and other personnel to discuss the outlines of the budget and personal and action plans of the next year.

In November and December, the budget for the next year is finalised and the teacher workload plans can be prepared for the next year using the workload information system. The middle managers also prepare the action plans and human resource plans with the rectors and directors of education using the management information system. Internal strategic negotiations are carried out to evaluate the objectives achieved and to set new targets for the planning period.

An important finding of the analysis is that the most important information systems for the degree programme managers are in the mechanical IEs and partly in the organic IEs, but only a minor part of the information systems are in the dynamic IE. This is striking because the innovations and competitive advantage of higher education institutions can typically be found in the dynamic IEs of subunits in contact with external partners, stakeholders of the HEI, students, and customers.

The customer relationship management (CRM) system can be one way to open the information systems to the networks of the environment. Another way is to develop the mechanical and organic environments to be more dynamic by adding interactive elements to them. The third possible way is that the dynamic areas could be managed and used with the development and support service managers by developing the social networks of the large organisation by developing coordinating activities across units with the help of the management information system using the group work Web and mobile applications.

CONCLUSION

The role of middle managers has become more important as the autonomy of HEIs has increased. The information intensive processes have attained a remarkable role, as the competition in education has increased. Clearly, there is a need for dynamic IEs, where innovations emerge with the connection to working life. Dynamic IE is a platform where we could expect new innovation in information and communication technology.

This study identified the creative class in the TUAS. The creative class is a group of personnel who work in dynamic information environments and use information and communication technology in a creative way. It turned out that mainly the middle managers belong to this creative class. They use and develop the information systems in an innovative way. There are also many other people who spontaneously take the responsibility for developing the information systems and whose expertise is best suited to these projects.

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KEY TERMS

Dynamic Information Environment: The virtual interface of the organization for links to the world outside. The main idea of the dynamic information environments is a strategic awareness of the potential for virtual learning, interaction, and communication.

Higher Education Institution: Higher education institutions include traditional universities and profession-oriented institutions, in Finland called universities of applied sciences or polytechnics.

Information Environment: A mechanical, organic, or dynamic area of information management consisting of different interrelated and/or isolated information systems.

Information System: A system, whether automated or manual, comprising people, machines, and/or methods organized to collect, process, transmit, and disseminate data that represent user information.

Knowledge Management: A term applied to the techniques used for the systematic collection, transfer, security, and management of information within organizations, along with systems designed to assist the optimal use of that knowledge.

Management Information System: A proper management information system entails modeling the entire management process and tailoring all necessary components of the information technology support system to meet the needs of the organization. The management information system should include a description of strategic objectives and of measures to achieve them.

Social Capital: The social relations between individuals in the organization lay the foundation for the social capital of the organization.

I

Integrating Software Engineering and Costing Aspects within Project Management Tools

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INTRODUCTION

Currently, there is no integration among CASE tools (computer aided software engineering, also named AMD tools, analysis modeling and design), costing tools, and project management (PM) tools. Not only are there no integrated tools, but there is also no conceptual integration among software engineering (SE) aspects and accounting-costing aspects of software projects within PM tools. PM tools, as well as costing tools are used not only for tracking and controlling an ongoing software project, but also at the very beginning stages of the project, in which critical estimations concerning budget and time frame are made. In order to have a firm, robust, and accurate planning, project planning should be based directly upon raw SE components-objects, that is, upon analysis and design components-objects.

According to the Standish Group CHAOS Report 2003, each year in the USA there are approximately 175,000 projects in IT Application Development which spends $250 billion. Among these, 31.1% of projects will be cancelled, 52.7% of projects will cost 189% of their original estimates, only 52% of required features and functions make it to the released product, and Time overruns 82%. In financial terms $55 Billion dollars is wasted in these projects (Madpat, 2005).

Budget overrun indicates cost management problems, although this area is defined by the project management integration (PMI), as one of the nine core activities of projects management. Costing difficulties result from both implementation limitations of costing solutions in complex and changing requirements as well as the technological environment. Risk management is also defined by the PMI as one of the nine core areas of project management; but there is also no integration between PM tools and SE tools in light of the need for risk management.

According to Maciaszek and Liong (2005), success of a software project depends on five software engineering areas that are related to each other: the development of the life cycle of the software, processes management, the model's configuration and language, and SE tools and project planning. The combining between formal tools of SE and PM processes in the different stages has been proved by research as holding a positive contribution to the efficacy of the project and as an improver of the adherence to costs, technical requirements, and the schedules that were allocated to the project (Barker & Verma, 2003).

This study proposes and prototypes a model that integrates these three aspects of software projects by automatically mapping SE objects and accounting–costing objects into PM objects. To validate the feasibility of the model and without loss of generality, it is demonstrated using former research platform focused on conversion of data flow diagrams (DFD), which are actually full enterprise set of use cases diagrams reflecting entire system-software project into Gantt charts.

BACKGROUND

CASE and PM Tools

CASE/AMD tools support the analysis, design, construction, and implementation stages of the information system life cycle (ISLC) (Barker & Longman, 1992; Pendharkar, Subramanian, & Rodger, 2005; Sommerville, 2004). Commercial tools, such as IBM–Rational XDE, are covering main stages of ISLC; the "Requisite-Pro" module, for instance, is designated to the stage of requirement definition, "Rose" module to the analysis and design stage, and "Test-Studio" module to the testing stage.

Although PM tools support management and control along the ISLC, there is hardly any integration between CASE tools and PM tools. Thus, ISLC modeling approaches, such as the functional approach (e.g., DFD, ERD, STD), as well the object-oriented approach (e.g., use cases, activity diagrams, STD), even when automated, are used mainly in the early analysis stage primarily for visual documentation. The "database of specifications," laboriously elicited and gathered during the creation of modeling diagrams, is hardly ever applied again for project management purposes, even though this information is valuable for project managers who are involved in the construction and implementation stages. In fact, due to lack of integration along the ISLC, the specifications database is often either overlooked altogether or collected again as if their creation earlier never took place. Moreover, standard methods for system analysis and development usually make no reference to methods for project management. Accounting and costing parameters, which are reviewed at the next chapter, are not represented not at SE tools or at PM tools, and handled in totally separated systems.

One conclusion that emerges from a thorough review of software engineering and project management areas is that SE tools are much more heterogeneous than PM tools. Gantt and Pert charts have become dominant project management modeling tools (Fox & Spence, 1998; Hughes & Cotterell, 2002) and are currently included in standard PM software such as Microsoft Project, PS-Next, and others. A survey of 1,000 project managers has found that 48.4% use MS Project, 8.5% use MS Excel, and the rest use Gantt/Pert-based tools from other vendors. The average satisfaction from PM tools in this survey was 3.7 on a scale of 1 to 5. Another survey reveals that only 10% of 240 project managers do not use PM tools at all, down from 33% in 1996. Moreover, more than 50% use Gantt/Pert-based project management software to manage every project, independently of its application domain and characteristics.

In contrast, the following two commercial CASE software packages demonstrate the heterogeneity of tools in the area of software engineering. Oracle's *Designer* supports functional hierarchy analysis based on Barker and Longman (1992) methodology, and IBM-Rational offers XDE-*Rose*, a modeling tool based on the unified modeling language (UML) only. PM tools thus seem more standardized and mature than CASE tools. This could be the reason why 71% of 397 software engineers surveyed in 20 European countries employ PM tools while only about 26% utilize CASE tools, despite similar levels of training (Domges & Pohl, 1998).

Although CASE tools, including those mentioned above, support teamwork, none contain elements that take into consideration teamwork planning, time planning, dependencies, resources allocation, cost estimation, or risk management. Moreover, none include Gantt or Pert models or offer built-in interfaces to PM tools. Methodologies and models for managing software projects have yet to make it from the idea to the product phase, despite persistent improvements in automated tools for requirement definition, systems modeling, and software engineering. The failure to transform project management theory to practice in the context of software development is especially troubling since more than 50% of such projects do not succeed (Madpat, 2005; Reel, 1999). In addition to the lack of integration between SE tools and PM tools managers in charge of software projects usually refrain from basing managerial judgement on data about requirements and functional characteristics of the specific development project (Reel, 1999).

With decades of systems development behind us, there is quite a consensus today with respect to the critical success factors (CSF) of system development projects and agile methodologies, there is still a need to introduce effective concepts, methods, measures, and tools for better control of software projects. All these observations lead one to conclude that assembling a repository of system requirements and system components, complete as it might be, does not guarantee effective planning of teamwork, scheduling of tasks, and controlling deviations between planned milestones and actual progress.

Against this background, the questions to consider are:

I. Is the gap between SE tools, costing methods, and PM tools is bridgeable?
II. Can SE components, collected by CASE tools, become directly available for the use of cost estimation, risk management, and directly integrated within PM without being subjectively interpreted or biased?
III. Is there a way to improve software modeling and engineering by introducing a managerial perspective in addition to the technical perspectives?

Our preliminary answers to those questions are "yes." This study proposes and prototypes a model that integrates these three aspects of software projects by automatically mapping SE objects and accounting–costing objects into PM objects. We have engaged in symmetry–isomorphism research with respect to distinct methodologies for software engineering and project management. Since Gantt chart is a technique for visual description of networks, the ability to convert DFD model or hierarchical use-case model to a network format is at the basis of our symmetry–isomorphism research. It is our intention in this article to demonstrate, based on this research, a possible integration scheme and provide more robust answers to the above questions. Given the wealth of CASE and PM tools, this work refrains from developing yet another one, but prototyping an integrated platform built-up of common CASE tool, costing models, and common PM tools. We show that combining these sets of capabilities can create the desired synergy where the whole is greater than the sum of its parts.

Costing Aspects and Methods

Detailed costing information is expected to include all types of costs that are required for manufacturing a product-software or providing a service. Data based on financial systems, which contain costs, derived from the income statement and the estimation of the company's capital and assets, enclosed the historical execution data and future estimations and forecasts (Roztocki & Needy, 1999). Williams (2004) supports the integration approach according to the conception that a modern accounting system is supposed to supply a framework for strategic management of the company's resources. In order to realize this conception, Williams proposes a multidimensional construct that clusters information from the company's systems on customers base, activity areas, and more for the purpose of forming an accounting system that facilitates planning, improvement and control, analysis and regulation of resources, and enhancement of profitability. Such a system is based on integrative information from a number of systems or from the arrays DW (data warehouse), BI (business intelligent) in five areas: costs, assets, quality/service, time, and outputs. The pioneers of the combining of financial and operational information are Cooper and Kaplan who developed the method of activity based costing (ABC) at the end of the 1980s. Cooper and Kaplan (1998) suggest in light of the technological development of information systems to define the integration between operational and financial systems for the purpose of building an accurate costing model.

In light of the above, establishment of integration conception required the definition not only of an enterprise costing model but also the definition of interfacing between the different areas and systems, that is, interface between SE aspects tools, financial aspects tools, and PM tools. Cost management is a term used for a wide description of short-term and long-term managerial activities involved in planning and controlling of costs (Horngren, Foster, & Datar, 2000). Table 1 presents variety aspects of costing model in a technological projects environment.

Costs analysis within the framework of technological environment must be carried out with the understanding of the project life cycle. Kerzner (2000) portrays the distribution of the project's cost over the project's life cycle:

- 5% - Conceptualization
- 10% - Feasibility study
- 15% - Preliminary planning
- 20% - Detail planning
- 40% - Execution
- 10% - Testing and commissioning

Tasks in each of these stages are described under the work breakdown structure (WBS). The WBS represents the required activities for the project's management in a hierarchical structure. For each component of the WBS, an evaluation of direct and indirect (overhead) costs must be included. Direct costs are divided to work's cost (usually work hours multiple hourly rate) and direct costs that are not work payment such as travel, materials, and so forth. It is recommended that these costs will include managerial reserve as well (Jurison, 1999).

Table 1. Aspects of costing model in a technological projects environment

	Aspect	Description	Difficulties
1.	**Planning**	Costs estimation of the project and for each resource in the projects portfolio	Defining direct and indirect resources and their costs
2.	**Controlling**	Costs analysis for each project and executed task	Attributing in-reality-costs to each project's task
3.	**Timeline**	Costs analysis over different time periods in planning and execution	Evaluating capacities of resources consumption over specified time periods
4.	**Tasks**	Identification and costing of project's tasks (WBS items)	Matching the costs to each of the project's components
5.	**Overhead Allocation**	A precise allocation of indirect costs	Determining the indirect cost generators in project's tasks
6.	**Risk management**	The inclusion of risk element and its value as part of the costing	Estimating risk on the basis of risk factors in the different tasks
7.	**Scenarios**	The ability to analyze alternative modes of action and costs	Defining assumptions and alternatives to the mode of cost's calculation
8.	**Profitability Analysis**	The understanding of the profit that derives from each of the projects and the whole projects portfolio	The inclusion of all the cost factors in the model

A reinforcement of the need to include the project's tasks (or the WBS components) in a costing model is intensified in the light of the cost estimations that are founded on work hours' evaluation. It has been argued (Ooi & Soh, 2003) that according to traditional approaches of software costing (time-based estimations), there may be a bending towards time planning without linking it to the specific task and the role player that performs it. Therefore, it is suggested to include the detailing of the tasks (Ooi & Soh, 2003) and/or an elaborate planning of the various project's resources as part of the costing model. The advantages of the resources' cost analysis throughout activities/tasks are more detailed information for managers, monitoring abilities, analysis of resources' cost and allocation, and a more accurate ability of overhead allocation (Jahangir, 2003; Kinsella, 2002; Ooi & Soh, 2003; Raz & Elnathan, 1999).

Indirect costs (overhead costs) include all types of costs that cannot be attributed directly to a specific task in the project marketing and sales expenses, office supplies, buildings' cost, professional services, information systems, computerization infrastructure, and the like. These costs are only occasionally incorporated in the project planning, but they carry great influence on the profitability of the portfolio and the projects' pricing decisions (Horngren et al., 2000). These costs are described as one of the "major headaches" (Kerzner, 2000). However, in this context, it has been argued that the ability to control costs is largely dependent on the monitoring of these costs.

Table 2 summarizes costing methods according to financial and engineering literature. The table also presents the common evaluation of model compatibility in light of entire costing aspects.

- **Analogy:** Cost estimation based on previous experience, using case-based reasoning (CBR) techniques. The accuracy of this method ranges from –10% to +25% (Kerzner, 2000).
- **Parametric:** Cost estimation based on heuristics and thumb's rules (Jahangir, 2003). Similar to the analogy estimation method, a parametrical model is also based on accumulation of historical data of project costs. On the basis of these data, a mathematical model is defined for the prediction of costs (Kinsella, 2002). The level of accuracy of a parametrical model ranges on a wide scope of –25% to +75% (Kerzner, 2000).
- **Function points:** A method that was first introduced in 1979 by Albrecht. Its objective is to

Table 2. Costing methods according to financial and engineering literature

			Planning	Controlling	Time Line	Task Resolution	Overhead Allocation	Risk Management	Scenarios	Profitability Analysis
Software Eng.	Top Down	Analogy	√ *	P*	X	X	P*	X	X	X
		Parametric	√ *	P*	X	X	P*	P*	√	X
	Bottom Up	Function Points	√	X	X	√	P*	√*	√	X
		COCOMO II	√	P	X	√	P*	√	√	X
Costing		Target Costing	√	P	P	P*	P	X	P	√
		Standard Costing	√	P	√*	√*	P	X	√	P
		ABC	√	P	P*	X	√	X	√	√

√ - *Good compatibility; X - No compatibility; P - Partial compatibility; * - Adjustments are required*

assess the software system's size while using the user's requirements without direct dependence on the technological realization (Hale & Smith, 2001). The function points method is calculated in three steps using the quantity and complexity of the functional components and the system attributes (Kemerer, 1993).

- **COCOMO (constructive cost model):** The model was first introduced in 1981 and since then several modifications were made in order to suit fourth generation languages, decrease in hardware costs, increase in quality assurance (QA) levels, advanced and agile development methods. The current version, COCOMO 2.0 (Boehm, Clark, Horowitz, Madachy, Sclby, & Westland, 1995), is not based upon line of codes but on four sub-models that match a spiral approach of software system development that are applied according to the stage of the life cycle (the application-composition model, early design model, reuse model, and post-architecture model).
- **Target costing:** Suits engineering framework in which there are several engineering activities simultaneously and is utilized as a means for costs strategic management. The idea behind the method is that a product's cost must be based on the sum that can be received for it in the market, and in other words, the development cost should be the basis for the quantity and mode of investment in the development rather than the development's outcome.
- **Standard costing:** Ascertains the cost framework while employing the amount of direct cost components and a standard price that was set for this unit. We shall formulate it concisely as:

$$TotalCost = \sum_{i-1}^{n} Qty_i * StdP_i.$$

It should be accentuated that the standard price does not solely include the direct price of the component (price per working hour) and is intended to contain the meaning of the cost or the consumption of indirect resources (rent, computerization, etc.). In the calculation of the standard price, it is customary to rely on known performance data from the past (Horngren et al., 2000).

- **Activity based costing (ABC):** Considered one of the advanced models for predicting costs while incorporating managerial decisions. The model was developed in the 1980s and its main innovation is in the addition of nonfinancial elements to the costing model. The model is widely used in a variety of industries such as agronomy, banking (Kao & Lee, 2001), and medicine. In the projects area, there is not much literature that discusses the application of ABC; however, there are a few studies that help to understand the method. These studies include the description of the method for software developing and assimilation (Ooi & Soh, 2003), the portrayal of the mode in which ABC can be taken on in projects (Raz & Elnathan, 1999), the implementation of ABC in favor of IT cost analysis in the organization, and a recommendation to include this model in the project management body of knowledge, or PMBOK (Kinsella, 2002).

THE INTEGRATED MODEL

The integrated model is based upon former research (Gelbard, Pliskin, & Spiegler, 2002) that has mapped data flow diagrams, which are actually comprehensive enterprise sets of use cases diagrams reflecting entire system-software project into Gantt charts. Current research is focused on the following extensions:

- Extending the database schema, used as the integrated system repository, in a flexible way enabling the addition of any costing parameter to each of the DFD/use case/SE components.
- Adding specific manipulations and outputs in order to support presentation of costing aspects.

Mapping DFD/Use Case Objects into Gantt Objects

As suggested in former research (Gelbard et al., 2002), data flow diagrams as well as use case diagrams can be mapped into Gantt charts based on the following conversions:

1. Each of the external entities are represented once only for input (if they produce input) and once only for output (if they produce output).
2. Each read only (RO) data store and each read/write (R/W) data store are represented once only for input and once only for output.
3. Each basic flow appears once only in every Gantt diagram.
4. Each basic process appears once only in every Gantt diagram.
5. OR connections between flows are not represented in the absence of parallels in Gantt diagrams. Logical connection traits between flows can, however, be included within basic process characteristics, thus maintaining mapping completeness.
6. A general process is represented by means of a summary task, that is, a grouping of activities and flows under a general name.
7. General flows are those that connect between summary tasks.

Example: Mapping of Hierarchical DFD

DFD as well as use case methodology enable hierarchical analysis of systems. The hierarchical description is achieved by "blowing up" general processes-usages into dedicated diagrams. Those dedicated diagrams represent lower level descriptions and can be composed of basic processes, general processes, and of "includes" and "extends" use cases. The hierarchical description can be halted when there are no more general processes at the lowest-level diagrams. Except for the root level, identified as "DFD-0," each diagram in the DFD hierarchy is identified by the respective general function, and the same can be defined for use case diagrams. For the sake of simplicity, the DFD used in the examples below contains only the following objects: basic and general processes, flows, external entities, and data stores. Processes are symbolized by ellipses and denoted by **P#**, entities by rectangles and **E#**, and flows by arrows and **#**.

Figures 1 and 2 demonstrate a hierarchical DFD. Figure 1 describes the root level with Basic Process P2 and General Process P1 (a general process is depicted by concentric ellipses). Figure 2 describes a lower level description of the General Process P1.

A composite DFD, made up from both DFD-0 (Figure 1) and DFD-1 (Figure 2), is shown in Figure 3. A composite DFD, not a typical or common representation of a hierarchical DFD, is included here because of its similarity to Gantt diagram representation, where summary tasks and subtasks can be displayed on the same diagram. A summary task represents, in the mapping model, a general process, while each subtask represents a component at the respective hierarchical DFD level. As can be seen in the fourth section, Figure 6 depicts the Gantt diagram corresponding to DFD-0 in Figure 1, and Figure 7 depicts the mapping of the composite DFD in Figure 3 into a Gantt diagram.

Figure 1. DFD-0

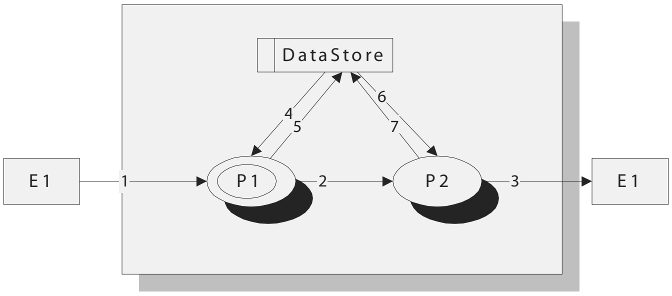


Figure 2. DFD-1 ("Blow-up" of General Process P1)

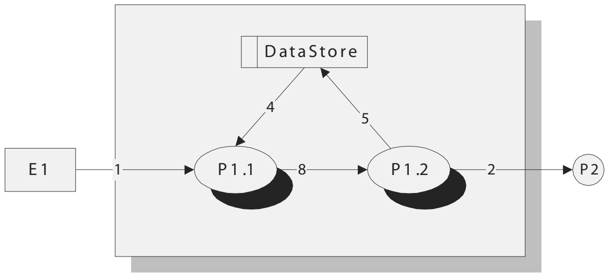


Figure 3. A composite DFD representing both DFD-0 and DFD-1

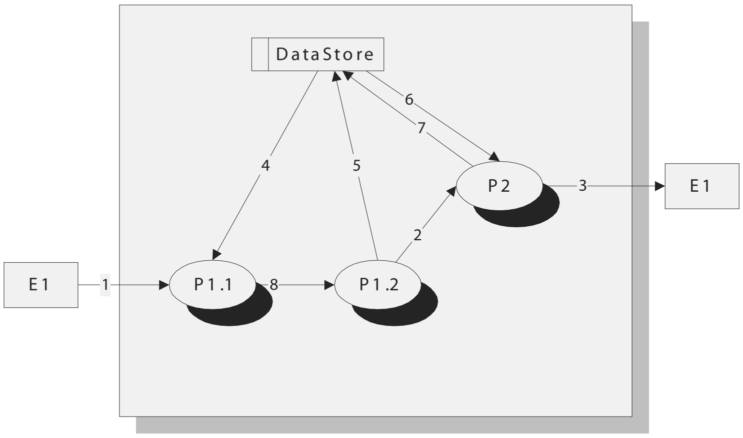
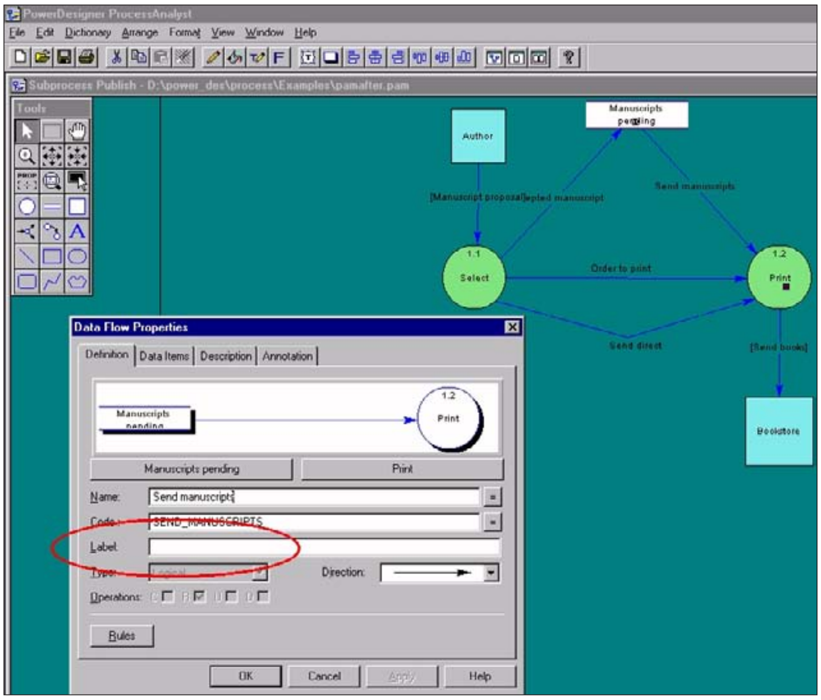


Figure 4. The "Label" input box used to insert costing aspects and values



Adding Costing Aspects

In order to enable location of any costing parameter to each of the DFD/use case models, we have used predefined symbols for each costing aspect. Noting a symbol with a numerical parameter beside it, in the "Label" input box at any "engineering" object dialog box, as shown in Figure 4, inserts relevant costing value (in light of the relevant costing aspect) to the relevant software component. A parser, running over the CASE repository, recognizes those predefined symbols and allocates the costing data in the integrated repository for further manipulation and interchanges. Overheads (indirect costs) inputs are made as labels of the entire project (the DFD-0 object itself).

The Integrated Repository

As mentioned above, the database schema, used as the integrated system repository, was extended in a flexible way so it is possible to add any costing parameter to each of the DFD/use case/SE components. Figure 5 illustrates the integrated database schema, which supports engineering objects (DFD/use cases), PM objects (WBS and ascription of dependencies), and costing objects (costing aspects and values). The integrated repository contains three main components: SE components, PM components, and costing components.

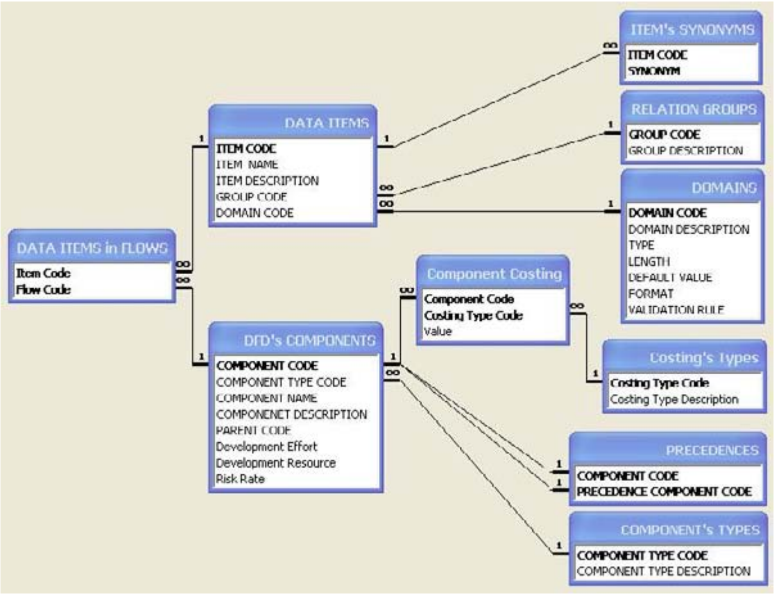
The SE component is based upon the following tables:

- Objects Dictionary = Tables: [DFD's COMPONENTS], and [COMPONENT's TYPES].
- Data Items Dictionary = Tables: [DATA ITEMS], [ITEM SYNONYMS], [DOMAINS], and [RELATION GROUPS].
- Ascription of Data Items to Basic Flows = Table: [DATA ITEMS in FLOWS].

The PM component is based upon the following tables:

- Ascription of dependencies between SE objects = Tables: [DFD's COMPONENTS], and [PRECEDENCES].

Figure 5. Database schema of the integrated repository



The costing component is based upon the following tables:

- Ascription of costing aspects and values to each SE object = Tables: [DFD's COMPONENTS], [Component Costing], and [Costing's Types]

In this way, those components enable representing and manipulating of DFD objects, costing aspects, and Gantt objects. The [PRECEDENCES] table stands for many-to-many network relationships as required for a Gantt representation.

In Figure 5, rectangles represent database tables, with the table name contained in the blue header and the primary key bolded. Lines between rectangles represent the database constraints (foreign key) and indicate the cardinality (one-to-many) of the relation. To distinguish between the various DFD/use case components, each component, in the [DFD's COMPONENTS] table, is attributed to a component type, defined in the [COMPONENT TYPES] table. The [Cocting's Types] table stands for the variety of costing aspects, while the [Component Costing] represents many-to-many relations between SE component-object and costing aspects. The specific value of costing aspect of the relevant SE component-object is stored in this table (in the [Value] field).

THE PROTOTYPE

Data flow diagrams where constructed by using the CASE tool "Power Designer; Process Analyst," and it is worth mentioning that the same can be done for use cases using the same tool. Costing aspects and values were referenced to each SE component (see Figure 4). A parser while running over the CASE repository inserts accordingly the relevant records to the integrated database schema, as described in the third section and illustrated in Figure 5. Then, the prototype activates MS Projects and MS Excel, creating project Gantt charts (by MS Project), and project summation (by MS Excel). The following figures illustrate two kinds of outputs: "classic" PM outputs and costing outputs. "Classic" PM outputs relate to Gantt chart, while costing outputs relate to project summations.

"Classic" PM Outputs

DFD models shown in Figures 1, 2, and 3 were mapped into MS Project Gantt charts. Figure 6 displays the Gantt chart corresponding to DFD-0 in Figure 1, and Figure 7 displays the mapping of the composite DFD in Figure 3 into a Gantt chart. The Summary Task P1 in Figures 6 and 7 (line 10) corresponds to General Process P1, while subtasks of P1 are represented only in

Figure 6. Ms Project Gantt chart representation of Figure 1 DFD's objects

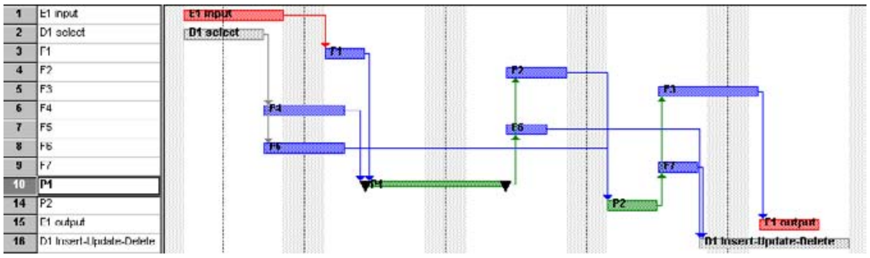


Figure 7. Ms Project Gantt chart representation of Figure 3 DFD's objects

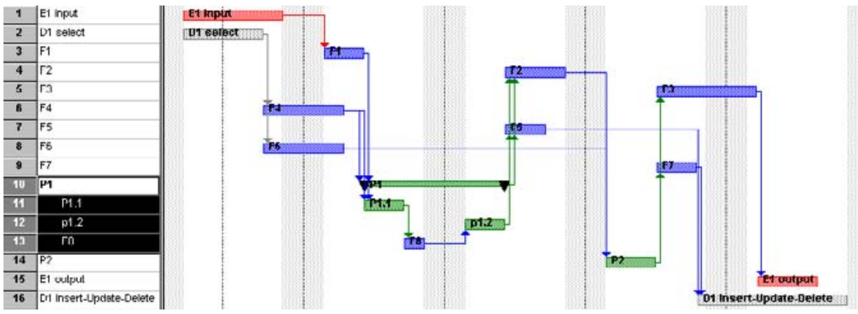


Figure 7. The P1 Summary Task has a distinct symbol with emphases at the edges.

Double clicking on line 10 "blows up" the summary task and displays its subtasks. Lines 11, 12, and 13 in the Gantt chart of Figure 6 are hidden because they are related to a lower level in the DFD hierarchy, DFD-1 (Figure 2). Lines 11, 12, and 13 in Figure 7 represent the DFD objects that are shown in DFD-1 (Figure 2).

Costing Outputs

Costing aspects of risk and direct costs where constructed by using the "Label" input box (see Figure 4). A parser, while running over the CASE repository, inserts accordingly the relevant records to the integrated database schema and then activates the Visual Basic Excel module, which has created a project summation accordingly. Hierarchical presentations were applied using built-in features of MS Excel.

Figures 8 and 9 illustrate hierarchical presentations of the same DFD models shown in Figures 1, 2, and 3. Figure 8 displays the summation corresponding to DFD-0 in Figure 1, and Figure 9 displays the summation of the composite DFD in Figure 3. The Summary Task P1 in Figures 8 and 9 (line 13) corresponds to General Process P1, while subtasks of P1 are represented only in Figure 9. The P1 Summary Task has a distinct background with "+" sign beside it.

Risk was assigned separately to time, budget, and functional aspects of each SE component-object. Direct costs are presented in units of months. Further calculation can be made according to parameters of salary rates and overheads, presented in the "costing" sheet.

Double clicking on the "+" sign beside line 13 "blows up" the summary task and displays its subtasks. Lines 14 and 15, in the Excel spreadsheet of Figure 8, are hidden because they are related to a lower level in the DFD hierarchy, DFD-1 (Figure 2). Lines 14 and 15 in Figure 9 represent the DFD objects that are shown in DFD-1 (Figure 2).

DISCUSSION AND CONCLUSION

Current research demonstrates the derivation of PM objects and project risk and costing evaluation, directly on the basis of raw SE components-objects. By this, we provide an integrating layer, which combines standard PM tools with common system analysis and design tools and costing aspects and models. Applying such

Figure 8. Summary of risks and resources

Integrating Engineering & Accounting Aspects of Software Projects

WBS	Risk			Time Required by each Allocated Resource				
	Time	Budget	Function	AMD	Sys	UI	DB	Logic
E1-Input	!			0.5		2		
D1-Select		!		1			1	
F-1							0.5	
F-2							0.5	
F-3							0.5	
F-4							0.5	
F-5							0.5	
F-6							0.5	
F 7							0.5	
P-1			[!!!]	[1.5]	[1]			[3]
P-2				0.5	1			1
E1-Output				0.5		2		
D1-Insert-Update-Delete				1			2	

WBS / Costing

Figure 9. "Blown-up" of risks related to Process "P-1"

Integrating Engineering & Accounting Aspects of Software Projects

WBS	Risk			Time Required by each Allocated Resource				
	Time	Budget	Function	AMD	Sys	UI	DB	Logic
E1-Input	!			0.5		2		
D1-Select		!		1			1	
F-1							0.5	
F-2							0.5	
F-3							0.5	
F-4							0.5	
F-5							0.5	
F-6							0.5	
F-7							0.5	
P-1			[!!!]	[1.5]	[1]			[3]
P-1.1			!!!	1	1			2
P-1.2			!	0.5				1
P-2				0.5	1			1
E1-Output				0.5		2		
D1-Insert-Update-Delete				1			2	

WBS / Costing

an integrating layer in software development projects enables improved risk and cost estimations at the very beginning stages of a software project, as well as better monitoring and control over various topics uniquely related to software projects.

The integration model presented in this study has the following advantages:

1. The integrated model enables risk, effort, direct, and indirect cost estimation for software development to be an integral part of conventional analysis and design methodologies. This is due to the possibility of deriving assessments *directly from raw data stored at the repository of a CASE tool*, as opposed to relying on aggregates or other secondary sources.
2. The integrated model enables extension of the basic development time assessment beyond the mere aspects of time and direct cost *to include also risk, overheads, and any accounting-costing parameter*.

3. The integrated model bases the estimation process on the *very common management tools*, for example, MS Project and MS Gantt.
4. Use of Gantt charts enables *dynamic* control of the estimation, based on reports regarding *actual* progress. This provides for *projected-to-actual* comparisons of cost and *moment-to-moment* updates of CPM calculations, as opposed to the *static* control methods customary in the field of software development.
5. Use of Gantt charts allows *"drilling down,"* into the *system code design*, including master routines and system major service routines. This differs from current methods used for software development, which are limited primarily to the area of *functionality*.
6. The potential of a detailed drill-down concerning system code design provides for engaging and *integrating* the technical team (development managers) as early as the analysis stage. This results in a more *reliable* and *accurate* estimation base for the entire system development project.

It is noteworthy that conversion of a DFD model as well as of a use-case model into a Gantt chart is actually a representation of a knowledge model as a semantic network. We have reason to believe that the integration of SE aspects and costing aspects within PM tools, modeled and prototyped in this study, is not limited to the DFD/use-case approach or to the described costing methods, but can be applied to any "network-based" software engineering modeling, as well as to any additional costing method. The fact that DFD conversion into Gantt chart is actually a representation of a knowledge model as a semantic network opens opportunities for commercialization for practitioners.

In sum, this study showed the feasibility and validity of converting SE objects and the risk and the cost we ascribe to those software components into PM objects. The integration of common CASE tools with costing models and standard PM tools can potentially improve estimation, planning, and control of software development projects in terms of cost, time, and risk management. In software projects, where so many things may go out of control, any theoretical as well as practical novelty is required in order to gain additional progress.

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KEY TERMS

Activity Based Costing (ABC): A cost prediction model that has greatly improved the ability to predict a proper allocation of indirect costs among several activities and thereafter between many products. Before using this model, one has to appreciate and understand the overall business (including its production and marketing). The model is not always applicable: a cost-benefit analysis is necessary before a final decision is made.

CASE/AMD Tools: Software tools (Computer Aided Software Engineering), also named AMD tools (Analysis Modeling and Design), to assist entire System Life Cycle (SLC), including analysis phase, design phase, testing phase, and even maintenance phase. CASE/AMD tools support the fuctional analysis phase using visual modeling notations, which can automatically convert into code.

COCOMO (Constructive Cost Model): An estimation method used to assess the human effort required for software development, which was first introduced in 1981, and since then several modifications were made in order to suit fourth generation languages, decrease in hardware costs, increase in QA levels, and advanced and agile development methods. The current version, COCOMO 2.0 (Boehm et al., 1995), is not based upon line of codes but on four submodels that match a spiral approach of software system development that are applied according to the stage of system life cycle.

Function Points: An estimation method used to assess the human effort required for software development, which was first introduced in 1979. Method objective is to assess the software system's size while using the user's requirements without direct dependence on the technological realization. It is calculated in three steps using the quantity and complexity of the functional components and the system attributes.

Gantt Chart: A popular type of bar chart that illustrates a project schedule. Gantt charts illustrate the start and finish dates (ES, EF, LS, LF) of entire project elements. Project elements comprise the work breakdown structure (WBS) of the project. Gantt charts also show the dependency (i.e., precedence network) relationships between activities. Gantt charts can be used to show current schedule status using percent-complete shadings and a vertical "Today" line.

Modeling Languages: Visual-graphical notations used to express functionality, processes, structures, behavior, as well as technical aspects of a system. Modeling languages are defined by a consistent set of rules, which are used for interpretation of those graphical symbols. Among modeling languages, in the software domain, there are data flow diagrams, used for hierarchical functionality decomposing; process diagrams, used for business processes modeling; entity relation diagrams, used for data structure modeling; and state transition diagrams, used for behavior modeling.

Target Costing: A cost prediction model that suits an engineering framework in which there are several engineering activities which take place simultaneously. It is utilized as a means for costs strategic management. The idea behind the method is that a product's cost must be based on the sum that can be received for it in the market. It is therefore the development costs which should be the basis for the quantity and mode of investment in the development rather then the development's outcome.

UML (Unified Modeling Language): A standardized visual-graphical notation gathering together diverse modeling diagrams, which are required in order to define entire software system aspects. UML is officially defined at the Object Management Group (OMG) by the UML metamodel, a meta-object facility metamodel (MOF).

I

An Integrative Approach to User Interface Design

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INTRODUCTION

As we are witnessing an increase in multifunctionality of interactive devices, two problems are taking shape in user interface (UI) design: first, the problem of complexity, and second, the problem of fragmentation (Kljajevic, in press). The former is reflected in the fact that multipurpose interactive devices usually have interfaces that do not allow easy access to new functions and features, rendering the increased functionality useless. The second problem is related to the fragmentation in the current research paradigms and testing trends that inform UI design. These paradigms and trends stem mostly from psychological theories that focus on only some specific aspects of user-interface interaction. While it is important to investigate such topics in detail, it is even more important to look at the totality of the interaction and determine the principles that operate in it. An integrative approach to UI design has the potential to solve both problems. Such an approach has two components: a top-down and a bottom-up component. Its top-down component deals with a small set of basic cognitive principles that operate in interactive reality and therefore need to be recognized at the level of UI design. The principles are built into a cognitive architecture—a wide theoretical framework that corresponds to the human cognitive system—whose constraints prevent proliferation of implausible theories, which solves the fragmentation problem.

Since the principles within a top-down approach to UI design are too general and hard to quantify (Zacks & Tversky, 2003), its bottom-up component enables accurate specifications of each case of UI design. This is done via computational cognitive models. The models are used for rapid prototyping and evaluation, as well as for other requirements of iterative user-centered design. Thus, the integrative approach to UI design is a model-based design approach that unifies the domains of cognition, theory, methodology, and design in a principled way. The integrative approach emphasizes the principles that operate in all four domains with the domains functioning as different levels of representation and interpretation of interactive reality.

The integration of the levels is driven by the economy principle, the principle of information structuring, and the relevance principle. The proposed cognitive principles are derived from many domains of cognitive research. Each of the principles operates at each of the levels. Thus, the basic principles of cognition are extended to theorizing about interactive reality to the construction of methodological tools for its theories (e.g., modeling) and design of specific products' interfaces.

It might seem that UI designers should deal with the principles at the level of design only. Although the level of design is necessary, taken in isolation, it is insufficient for a well-designed interface. This is because (a) cognition is the crucial element of human-computer interaction; that is, designers need to understand the cognitive processes involved in it (Peschl & Stary, 1998); (b) without a theory of cognition, any model of dynamic, interactive behavior, be it verbal or computational, is random, theoretically unconstrained, and as such scientifically not valid; and (c) iterative design could only benefit from the models that fully employ insights from cognitive science.

THE INTERACTIVE REALITY

I will use the term *interactive reality* to refer to the context of interactive behavior emerging from a user-task-artifact triad. A specific case of interactive behavior depends on (1) the elements of the triad, (2) complexity of the structural relations among the elements, and (3) the environment in which a task takes place. Thus, the term *interactive reality* implies that no matter how complex the dynamic interplay of user's cognition, perception, and motor actions is, it is the totality of the relations that emerge from the triad in each particular case and the triad's interaction with the environment that determines the quality of the user's experience.

Given the complexity of interactive reality and that of the human cognitive system, it is confusing that UI design often assumes that the *rationality principle* is the only relevant principle that affects this reality. Indeed, cognitive scientists have long realized that "rationality does not determine behavior" (Simon, 1947, p. 241) and that the rational decision theory put forth by neoclassical economics is too idealized to be applied to everyday human life (Boden, 2006; Gardner, 1985).

As an example of irrational interactive behavior, consider "the paradox of the active user." The paradox consists in the user's preference of inefficient general procedures to the recommended specialized ones. Thus, the user's decisions on the steps in accomplishing a task are neither optimal nor rational choices. What is puzzling here is the users' persistence in employing the inefficient strategies even though in the long run these require more effort (Fu & Gray, 2004). More importantly, such behavior is guided by an inadequately designed UI. If the principle of rationality does not figure prominently in interactive behavior, then what are the principles that determine it? Here I outline three principles that appear to influence interactive behavior more than the principle of rationality.

DESIGN AS APPLIED SCIENCE

In a way, UI design seems to close the gap between "theory and practice," which has been open for millennia (Ohlsson, 2007). The distinction neatly emphasizes the divide between the two types of knowledge: theoretical type, or "knowledge that," and the practical type, or "knowledge how." UI design has the potential to become a mechanism for interfacing thought and action, bridging the big divide between theory and practice.

Card, Moran, and Newell (1983) have pointed out that knowledge of human behavior does not translate easily into guidelines on how to design interactive computer systems. In order to enable an easy transfer of knowledge from *theoretical psychology* to the *practice of design*, they proposed building "an *applied psychology* that includes theory, data, and knowledge" (p. vii). Within this applied approach, the key concept is *cognitive architecture* (CA), that is, a construct that attempts to explain the overall structure of the human cognition. CAs integrate the broadest range of human cognitive phenomena (attention, vision, working memory, decision making, problem solving, learning), which makes them (and cognitive science in general) perfectly aligned with a major desideratum of science—unification of "seemingly disparate events."

A cognitive architecture is a theoretical framework which hypothesizes about those aspects of the human mind that are relatively constant over time and across tasks (Sun, 2004). More specifically, a particular CA is characterized by specific constraints that prevent proliferation of implausible theories, while its model provides the architecture with the knowledge required for accomplishment of a certain task (Langley, Laird, & Rogers, 2006). Computational cognitive models are runnable, and can be used to test parameters and sequences of human behavior that otherwise could not be tested, such as prohibitive costs or impracticality due to time limits (Byrne, 2002). They also enable making quantitative predictions about users' performance (such as error and learning rates, or transfer of knowledge), which makes them a valuable tool in UI design and usability testing.

In addition to CAs, the integrative approach to UI design also relies on the unification of the levels of interpretation and representation of interactive reality (cognition, theory, methodology, design) via basic cognitive principles. This type of unification reflects the general trend towards minimalism that is currently present in science and in design. However, minimalism itself is only a by-product while the main indicators of a well designed interface are usability and quality in use. The latter two concepts result from a complex process of user-centered design (Schneiderman & Plaisant, 2005). It is generally assumed that usability, together with functionality, reliability, efficiency, portability, and maintainability, determines quality of a software product. Note that there exists another concept—the *quality in use*—that refers to a user's view of the quality of the system containing the software (*ISO 9126-4*). Quality in use may be influenced by any of the six software quality characteristics, but at the same time, it heavily depends on a user, task, and the context of use. Thus, the user-task-artifact triad and the interactive behavior within it directly determine the quality in use. Given the complexity of the human cognitive system on the one side, and that of interactive behavior, on the other, one could claim that usable interfaces cannot stem from the single principle of rational reasoning. Instead, they incorporate other, perhaps more relevant principles of interactive reality.

THE INTEGRATIVE APPROACH

The integrative approach to UI design extends the basic cognitive principles, such as the principle of economy, information structuring, and relevance to UI design. The approach implies that designers need to consider these principles at each of the following levels:

- The level of human cognition,
- The theoretical level,
- The methodological level,
- The level of interface design.

A dynamic interplay of the principles as well as the extrapolated levels are to be considered only through the prism of interactive reality. In other words, the purpose of a user-artifact interface is to enable communication between the two representation systems (user and device) and trigger an optimal cognitive dynamics in the user so that the task at hand can be accomplished by using minimal efforts for maximal benefits. This can be achieved by first constructing and then testing computational cognitive models of such interfaces.

The Principle of Economy

The most basic principle of human cognition is the principle of economy or "the least effort principle." It requires that the benefits of a particular action be maximized while keeping the costs or efforts required for its successful completion minimal. There is growing evidence indicating that this principle operates at different domains of cognition both in neurologically intact and impaired brains. As an example, consider the human conceptual system. Rosch (1978) has found that the principle of cognitive economy prohibits an endless creation of highly informative concepts. Since informativeness is cognitively costly, objects with similar features are grouped into the same category. So, instead of creating an infinite number of the most informative concepts, the human conceptual system categorizes the concepts according to their features into basic, superordinate, and subordinate concepts. Since basic concepts are more informative and distinctive than subordinate or superordinate concepts, our general preference is for the basic concepts.

The economy principle operates at the level of theory as well. At this level, it is known as Occam's razor. The general principle that "entities are not to be multiplied beyond necessity," which was put forth by a 14th century English philosopher and theologian, Ockham, has been adapted and widely used in science ever since as a principle according to which the best theory is always the one with the smaller number of assumptions and hypotheses (Blackburn, 1996, p. 268). Since a CA imposes constraints on theories developed within it, preventing proliferation of implausible theories, it is reasonable to assume that the theories developed within these wide frameworks would be inherently constrained and as such more aligned with the principle than the non-CA theories.

At the level of methodology, computational cognitive modeling seems to provide the most economical solutions. In addition to their capacity to make quantitative predictions about user's performance, including those aspects of interactive reality that would be impractical or impossible to test by the traditional methods, these models significantly reduce testing costs and time. One could object that building such models and becoming proficient in a CA are far from being effortless. However, the accuracy of distinctions and predictions, subtlety of concepts, and parsimony of models developed within a CA outweigh the efforts of learning how to build and use them.

When applied to the level of design, the economy principle translates into minimalism which in turn translates into efficiency—one of the usability subcharacteristics according to *ISO 9126-4*. For example, note that the economy principle might explain the paradox of the active user. As Fue and Gray (2004) have pointed out, users choose general and inefficient procedures possibly because such decisions "require less cognitive effort as mental look-ahead can be off-loaded to the external display" (p. 905). Thus, although users follow the economy principle (i.e., they choose the less difficult interactive actions that lead to incremental change), in the long run, they will invest more effort and time in the ineffective procedures. On the other hand, interfaces whose design incorporates the economy principle at all levels do not allow the paradox of the active user. Table 1 lists the principles and the levels of representation/interpretation of interactive reality.

The Principle of Information Structuring

"Cognition arises in response to the structure of external world" (Anderson & Lebiere, 2003). Since human cognition is limited with regard to the amount of information

Table 1. Interactive reality: principles and levels

Principle	Levels of representation and interpretation of interactive reality			
	Cognition	**Theory**	**Methodology**	**Design**
Economy→	The least effort	Occam's razor	Reduce procedures and rules	→ Minimalism
Information structuring →	Search for patterns; Sequence behavior; Establish hierarchies; linear ordering	Assign meaning: Describe & Explain	Model: Test & Predict Behavior	→ Functionality
Relevance →	Efficiency	CA constraints	Parsimony	→ Fitness for purpose

that it can process at a time, finding a structure in a stimulus facilitates its processing and remembering (Chater & Vitányi, 2003). Thus, the human cognitive system is always looking for patterns. Examples indicating that this principle holds abound both at low and high levels of cognition. For example, perception is extraction of patterns from sensory input. Language comprehension is extraction of patterns from language input for the purposes of communication. Learning, as well as conceptualization, categorization, inferencing, and other forms of higher cognition, are also based on search for patterns.

At the same time, human behavior is sequential and goal-driven. Its sequentiality is not obvious, since most activities in our daily lives leave the impression of continuity. The activities consist of more basic structural elements—actions, which are discrete, goal oriented, and hierarchically ordered elements of behavior (Zacks & Tversky, 2001). Actions are crucial at the level of interface design because they align the goal structure of an activity with the interface structure (Zack & Tversky, 2003). Thus, the goal of a UI designer should be the alignment of the two structures, and the instructions to users should reflect the hierarchical nature of actions.

The concept of decomposition of human behavior into activities and goal-directed actions was first used for computer modeling by Newell and Simon (1972). While their cognitive model, *General Problem Solver*, modeled only problem-solving for planning, the current cognitive architectures, such as ACT-R/PM (Anderson, Bothell, Byrne, Douglass, Lebiere, & Qin, 2004) in its most recent versions, model a wide range of human cognitive and perceptual-motor abilities (St. Amant & Riedl, 2000; Taatgen, Lebiere, & Anderson, 2006). ACT-R/PM is equipped for modeling of dynamic behavior such as interaction within the user-task-artifact triad. Indeed, ACT-R has been used for modeling situations such as driving and dialing a number on a variety of cellular phone interfaces (Salvucci, 2001; Salvucci & Macuga, 2001; St. Amant, Horton, & Ritter, 2006), proving that it is capable of providing valuable data in the iterative design process. Thus, information structuring is crucial not only in our representation and interpretation of the incoming information (via finding "patterns" in input data), but also in our production of outgoing information (sequencing of actions in everyday activities, establishing dependency and other relations within our mental representations). At the level of theory and methodology, the approach based on the concepts of cognitive architecture and computational modeling (like ACT-R) makes this important principle more visible.

The Relevance Principle

Given the economy principle, we would expect that finding patterns takes place with the least processing effort. On the other hand, the fact is that an infinity of patterns are in principle compatible with any finite set of data (e.g., an infinity of curves pass through a given set of points; an infinity of grammars are compatible with any finite set of sentences). Yet, the brain is looking for the simplest patterns as the ones that are the most "natural" to human cognition (Boden, 2006; Chater & Vitányi, 2003). Since finding the simplest pattern may in principle take more time and effort than finding a complex pattern, it seems that something else in addition to simplicity and economy drives the mind's search for patterns.

When choosing "the most natural" among the infinity of patterns that are compatible with any specific set of data, the human cognitive system is not searching for the simplest patterns only, but also for the most relevant among them. Providing the most relevant pattern maximizes "positive cognitive effects" in data processing (Sperber & Wilson, 1995) and optimizes the usefulness of information. This principle is also reflected in the fact that pattern recognition both in humans and machines is driven by elimination of redundancy (Chater & Vitányi, 2003). The principle has figured prominently in many domains of research: communication (Grice, 1989), inference, category-based induction, and relational reasoning, among others (Van der Henst & Sperber, 2004). Thus, UI design needs to acknowledge that the human cognitive system in its optimal state is geared towards efficiency—it automatically chooses to invest the least effort in picking the most relevant pattern from the stimuli, or in retrieving the most relevant information from memory. Although the principles are constant, each instance of UI design needs to reconcile them with the fact that interactive reality often assumes non-optimal cognitive states. Namely, factors such as fatigue, stress, illness, advanced age, and the contextual factors such as noise, movement, and multitasking—all affect the optimal state. Thus, UI design needs to apply the principles and be flexible at the same time.

CONCLUSION: UNIFICATION AT WORK

In this article, I have explored the ways in which three basic principles of human cognition influence theory and methodology of UI design. The basic assumption of the article is that the proposed principles operate at the disparate levels of representation and interpretation of interactive reality, such as human cognition, theory, methodology, and UI design. Another assumption is that human behavior can be modeled and that cognitive architectures offer a theoretical framework within which the modeling could bring design to bridge the gap between theory and practice.

If the principles described above hold, that is, if the human cognitive system indeed tends to automatically minimize effort, maximize relevance, extract optimal patterns form data, and choose optimal goals and subgoals for its actions, then it is possible, at least to some extent, to predict and manipulate the mental states of others. In other words, designers have an opportunity to drive users' attention in a way that would prompt exactly the choices that would cause an intended action. After all, the purpose of a user interface is to enable communication between a user and a device. The reason pop-ups are so annoying is that they break the communication between the user and device. The user's "relevance expectations" are not met (hence annoyance), which affects the user's attention and slows down his information processing. If the principles are indeed inherent to the human cognitive system, UI design needs to (1) make sure not to interfere with their working (producing "the paradox of the active user") and (2) prompt the user to keep applying them automatically. That would lead to the optimal design of user interfaces, that is, usability and quality in use with minimal cognitive effort.

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KEY TERMS

Cognition: A complex system enabled by the functioning of the brain. It comprises processes and states that include for example vision, language comprehension and use, memory subsystems, executive functions (planning, problem solving, self-monitoring), and so forth.

Cognitive Architecture: An underlying infrastructure of a cognitive agent that remains constant over time and across tasks. Cognitive architectures attempt to model the mind. Examples of cognitive architectures are SOAR, EPIC, ACT-R, and so forth.

Cognitive Principles: The principles that guide and restrict cognitive operations. They operate within and across different cognitive modules (vision, language, etc.). The most basic among these principles is the principle of economy, which requires that maximal benefits be obtained by the least cognitive efforts.

Interactive Behavior: Any behavior that emerges from mutual influence of the interacting elements. For example, interactive behavior within the user-interface-artifact triad depends on all three elements and the relations among them.

Quality in Use: Users' impression of the quality of a software product.

Usability: The term is usually taken to mean that a product is *easy to use* or "*user friendly*." In a more technical sense, the term refers to one of six software characteristics that a product has to have in order to achieve the quality set by the ISO standards.

User Interface: A medium of interaction between a user and a device. Users tend to identify an interface with the whole product because of the impression that they directly manipulate the objects on the screen.

Intelligent Multi-Agent Systems

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INTRODUCTION

Since the AAAI (http://www.aaai.org) Spring Symposium in 1994, intelligent software agents and agent-based systems became one of the most significant and exciting areas of research and development (R&D) that inspired many scientific and commercial projects. In a nutshell, an agent is a computer program that is capable of performing a flexible, autonomous action in typically dynamic and unpredictable domains (Luck, McBurney, Shehory, & Willmott, 2005). Agents emerged as a response of the IT research community to the new data-processing requirements that traditional computing models and paradigms were increasingly incapable to deal with (e.g., the huge and ever-increasing quantities of available data).

Agent-oriented R&D has its roots in different disciplines. Undoubtedly, the main contribution to the field of autonomous agents came from artificial intelligence (AI) which is focused on building intelligent artifacts; and if these artifacts sense and act in some environment, then they can be considered agents (Russell & Norvig, 1995). Also, object-oriented programming (Booch, 2004), concurrent object-based systems (Agha, Wegner, & Yonezawa, 1993), and human-computer interaction (Maes, 1994) are fields that have constantly driven forward the agent R&D in the last few decades.

In addition, the concept of an agent has become important in a diverse range of subdisciplines of IT, including software engineering, computer networks, mobile systems, decision support, information retrieval, electronic commerce, and many others. Agents are used in an increasingly wide variety of applications, ranging from comparatively small systems such as personalized e-mail filters to large, complex, mission critical systems such as air-traffic control.

BACKGROUND

Even though it is intuitively clear what an "agent" or "multi-agent system" is, we may say that there is no universal consensus over some key definitions among researchers in the field. One of the most broadly used definitions states that "*an agent is a computer system, situated in some environment, that is capable of flexible autonomous action in order to meet its design objectives*" (Jennings, Sycara, & Wooldridge, 1998, p. 8). There are three key concepts in this definition: *situatedness*, *autonomy*, and *flexibility*. *Situatedness* means that an agent receives sensory input from its environment and that it can perform actions which change the environment in some way. *Autonomy* is seen as the ability of an agent to act without the direct intervention of humans and that it has control over its own actions and internal state. In addition, the autonomy implies the capability of learning from experience. By *flexibility*, we mean the agent's ability to perceive its environment and respond to changes in a timely fashion; it should be able to exhibit opportunistic, goal-directed behavior and take the initiative whenever appropriate. Also, an agent should be able to interact with other agents and humans, thus be *social*. Some authors emphasize the importance of the concept of *rationality*, which will be discussed in the next section.

With an agent-oriented view of the world, it soon became clear that a single agent is insufficient. Most real-world problems require or involve multiple agents to represent the decentralized nature of the problem, multiple perspectives, or competing interests. Systems composed of multiple autonomous components (agents) are considered *multi-agent systems* (MAS) and historically belong to distributed artificial intelligence (Bond & Gasser, 1998). MAS can be defined as a loosely coupled network of problem solvers that work together to solve problems that are beyond the individual capabilities or knowledge of each problem solver (Durfee & Lesser, 1989). The characteristics of MAS are (Jennings et al., 1998):

- Each agent has incomplete information or capabilities for solving the problem, thus each agent has a limited viewpoint;
- There is no global system control;
- Data are decentralized; and
- Computation is asynchronous.

In addition to MAS, there is also the concept of a *multi-agent environment*, which can be seen as an environment that includes more than one agent. Thus, it can be cooperative, competitive, or both.

AGENT-BASED SOFTWARE AND MULTI-AGENT SYSTEMS

Agents and Environments

Dominant researchers in the field mostly refer to agents as software entities that perceive their *environment* through *sensors* and act upon that environment through *actuators* (Russell & Norvig, 1995). There is an obvious analogy with a human agent who has ears, eyes, and other organs as sensors, and arms, legs and other organs as actuators. Information about the state of the environment that the agent acquires through sensors is called *agent's percept*. An agent typically collects its percepts during the time, so its action in any moment generally depends on the whole sequence of percepts up to that moment. If we could generate a decision tree for every possible percept sequence of an agent, we could completely define the agent's behavior. Strictly speaking, we would say that we have defined the *agent function* that maps any sequence of percepts to the concrete action. The program that defines the agent function is called the *agent program*. These two concepts are different; the agent function is a formal description of the agent's behavior, whereas the agent program is a concrete implementation of that formalism.

As Russell and Norvig (1995) stipulate, one of the most desirable properties of an agent is its *rationality*. We say that an agent is rational if it always does the action that will cause the agent to be the most successful. The rationality of an agent depends on the performance measure that defines what is a good action and what is a bad action, the agent's knowledge about the environment, the agent's available actions, and also the agent's percept history. One of the most cited definitions of a rational agent is: "*for each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has*" (Russell & Norvig, 1995, p. 36).

The main challenge in the field of intelligent software agents is to develop an agent program that implements the desired functionalities. Since it is a computer program, we need to have some computing device with appropriate sensors and actuators on which the agent program will run. We call this *agent architecture*. Thus, an agent is essentially made of two components: the agent architecture and the agent program.

Another important concept in the field is the so-called *belief-desire-intention* (BDI) model (Bratman, Israel, & Pollack, 1988). BDI agents are characterized by a "mental state" with three components: *beliefs*, *desires*, and *intentions*. *Beliefs* correspond to information that the agent has about its environment. *Desires* represent options available to the agent—different possible states of affairs that the agent may choose to commit to. *Intentions* represent states of affairs that the agent has chosen and has committed resources to. An agent's practical reasoning includes constantly updating beliefs from information in the environment, deciding what options are available (i.e., recognizing its desires), "filtering" these options to determine new intentions, and acting on the basis of these intentions (Jennings et al., 1998).

Multi-Agent Interactions

In MAS and multi-agent environments, the individual agents need to interact with one another, either to achieve their individual objectives or to manage the dependencies that ensue from being situated in a common environment. These interactions range from simple semantic interoperation (exchanging comprehensible communications) through client-server interactions (the ability to request that a particular action is performed) to rich social interactions (the ability to cooperate, coordinate, and negotiate about a course of action).

We consider two basic types of agent interactions in MAS. *Cooperative* multi-agent interactions are guided by cooperation strategies meant to improve the collective performance. Internet-based information integration and interactive entertainment are examples of this approach. *Self-interested* multi-agent interactions consider agents that do not share common goals. Self-interested agents are centered around the notion of *negotiation*, which is seen as a method for coordination and conflict resolution.

In both cases, cooperative or self-interested agents have to communicate. Agent communication is achieved by exchanging messages represented by mutually understandable syntax and containing mutually understandable semantics. In order to find a common ground for communication, an *agent communication language* (*ACL*) should be used to provide mechanisms for agents to negotiate, query, and inform each other. The most important such languages today are *KQML* and *FIPA ACL*. KQML (Knowledge Query and Manipulation Language) (ARPA Knowledge Sharing Initiative, 1993) is a language that provides a framework for information and knowledge exchange among agents as well as between agents and other systems. FIPA (IEEE Foundation for Intelligent Physical Agents, http://www.fipa.org/) leads the agent development efforts towards a universal ground for cooperation among heterogeneous agents. Its main activity is focused on establishing standards for agent communication, where standardization of FIPA ACL (FIPA, 1997) and messages exchanged among agents represent the basis for interoperability. FIPA specifications and standards are widely accepted and supported by agent modeling frameworks (e.g., JADE, http://jade.tilab.com/).

Obstacles for agent communication stemming from the disperse nature of the agent world (e.g., finding one another) often imply a need for *middle-agents*, which facilitate cooperation among agents and connect service providers with service requestors. These agents are useful in various roles, such as *matchmakers* or *yellow page agents* that collect and process service offers ("advertisements"), *blackboard* agents that collect requests, and *brokers* that process both (Sycara, Decker, & Williamson, 1997).

Controversies and Pitfalls of Agent Development

It is not uncommon that some users, not having enough knowledge about intelligent agents, express concern (even fear) about their usage. They tend to confuse them with software daemons that send spam e-mail messages or with software viruses that can damage their systems. Skeptical views especially target autonomy stating that autonomy of a software entity leads to dependency of such an entity's "will."

In the field of software engineering, agents are also criticized. The critiques are primarily concerned with traps in which a developer may fall when developing agents. Those pitfalls include applying agent technology in areas where other software engineering concepts are more suitable, the inappropriate use of other AI techniques, the inadequate number of agents in an agent-system, and so forth. A tendency of building anarchic systems is particularly important pitfall regarding MAS. Structuring the society of agents usually leads to systems with reduced complexity and increased efficiency (Wooldridge & Jennings, 1998).

APPLICATIONS

Intelligent software agents are a suitable software engineering concept in a wide variety of application domains. Their characteristics (e.g., autonomy) qualify them for successful application in various fields: traffic and transportation control, computer networks and telecommunication control, health care, process control systems, and so forth. Information gathering, where agents are used for searching through heterogeneous information sources (e.g., World Wide Web) and acquisition of relevant information for their users, is also an important application domain. One of the most common applications in this domain is Web browsing and search, where agents are used for adapting the content (e.g., search results) to the users' preferences and offering relevant help in browsing. With the growing amount of data available on the Web, the role of agents in search is getting more and more attention.

Agent cooperation opens possibilities for applying multi-agent systems to solving constraint satisfaction problems. The auction negotiation model enables a group of agents to find good solutions by achieving agreement and making mutual compromises in case of conflicting goals. Such an approach is applicable to trading systems, where agents act on behalf of buyers and sellers. Financial markets, as well as meeting scheduling and travel arrangement composing, also represent prominent fields for agent application.

Intelligent tutoring systems often include pedagogical agents, which represent software entities constructed to present the learning content in a user-friendly fashion and monitor the user's progress through the learning process. These agents are responsible for guiding the user and suggesting additional learning topics related to the user's needs (Devedzic, 2006). In the design of user interfaces, agent technology may be used to create adaptable interfaces where an agent or an agent system tries to register the user characteristics and behavioral tendencies and to adapt the user interface to these observations (i.e., perceived requirements) by making interface more usable (Shneiderman & Plaisant, 2005).

BluScreen

BluScreen is a research project at the University of Southampton (http://www.iam.ecs.soton.ac.uk/projects/BluScreen.html), the main aim of which is to create an intelligent public display able to adapt the selection of adverts for display to the present audience detected by Bluetooth technology. Customization of content is achieved by using history information of past users' exposure to certain sets of adverts in order to predict which advert is likely to gain the highest attention.

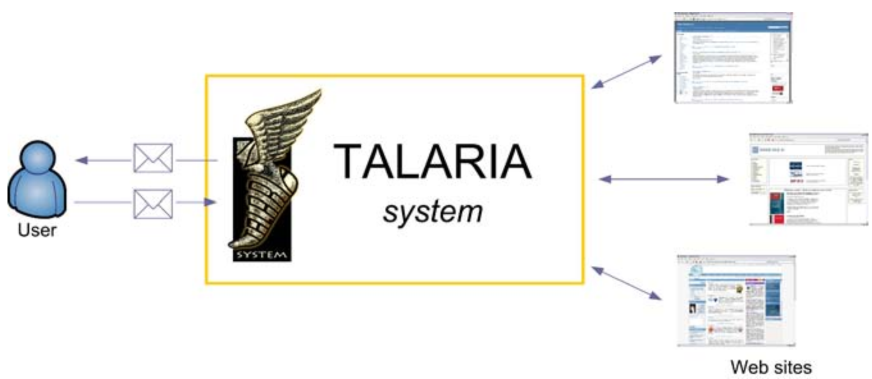
This multi-agent system employs an auction-based negotiation model. Each agent represents a stakeholder wishing to advertise, and it is provided with a bidding strategy that utilizes heuristics to predict future advert exposure, based on the expected audience composition. These agents compete in an auction to gain advertising space, ensuring that the most suitable advertising content is selected (Paine, David, Jennings, & Sharifi, 2006). BluScreen uses the concept of agents' socialization to achieve context aware, intelligent behavior of the system as a whole, relying on particular agents' autonomy to act on behalf of stakeholders and maximize their satisfaction.

Talaria

Talaria System (The Autonomous Lookup and Report Internet Agent System), named after the Greek Messenger God Hermes's winged sandals, is a multi-agent system developed for academic purposes at the School of Business Administration, the University of Belgrade, Serbia (http://goodoldai.org.yu/talaria/). It offers a solution to the common problem of gathering information from diverse Web sites that do not provide RSS feeds for news tracking. Talaria integrates information gathering and filtering in the context of supporting a user to manage Web interests. The system provides each user with a personal agent, which periodically monitors the Web sites that the user expressed interest in. The agent informs its user about relevant changes, filtered by assumed user preferences and default relevance factors. Human-agent communication is implemented via e-mail so that a user can converse with the agent in natural language, whereas the agent heuristically interprets concrete instructions from the mail text (e.g., "change site list" or "kill yourself").

Human-like interaction, autonomy-related aspects of this system, and acting on behalf of the user emphasize the usability advantages of this agent-based software.

Figure 1. TALARIA system



The system was implemented using the JADE modeling framework (http://jade.tilab.com/).

FUTURE TRENDS

The development of agent technologies is closely related to broader visions and trends in IT that are about to drive forward the whole field of intelligent agents. We especially emphasize *the Semantic Web*, *Web services*, and *ambient intelligence*. *The Semantic Web* is the vision of the future Web based on the idea that the data on the Web can be defined and linked in such a way that it can be used by machines for automatic processing and integration (Berners-Lee, Hendler, & Lassila, 2001). The key to achieving this is by augmenting Web pages with descriptions of their content in such a way that it is possible for machines to reason automatically about that content. The Semantic Web offers a solid ground for further development of the agent technologies as well as successful deployment of a variety of agent-based applications, and we share the opinion that the Semantic Web itself will be a form of infrastructure for intelligent agents and MAS.

The other important drivers of agent development are the *Web services* and *service-oriented computing*, which are likely to become the dominant base technology in the foreseeable future. The Web service technology provides standard means for establishing interoperability between heterogeneous software applications that run on a variety of different platforms. Accordingly, this technology is almost ideal for use in supporting agent interactions in a multi-agent system (Booth, Haas, McCabe, Newcomer, Champion, Ferris, & Orchard, 2004). The concept of *ambient intelligence* is an idea that describes a shift away from PCs to a variety of devices which are unobtrusively embedded in our surroundings and which are accessed via intelligent interfaces, with no doubt require agent-like technologies in order to achieve autonomy, distribution, adaptation, and responsiveness (Luck et al., 2005).

The majority of today's most significant IT visions and trends, such as the abovementioned and many more, will require agent technologies (or something similar to them), before being fully implemented. Agent technologies are upstream of these visions and mission-critical to them. However, to be able to support these visions, the agent-based computing needs further development and strengthening. Some considerable challenges have remained in the agent-based world, among which we emphasize the lack of sophisticated software tools, techniques, and methodologies that would support the specification, development, integration, and management of agent systems.

CONCLUSION

Research and development in the field of intelligent agents and MAS is rapidly expanding. It can be viewed as a melting pot of different ideas originating from various areas such as artificial intelligence, object-oriented systems, software engineering, distributed computing, economics, and so forth. At its core is the concept of autonomous agents interacting with one another for their individual and/or collective benefit.

A number of important advances have been made over the past two decades in design and implementation of individual autonomous agents and in the way in which they interact with one another. These concepts and technologies are now finding their way into commercial products and real-world software solutions. Future IT visions share the common need for agent technologies and prove that agent technologies will continue to be of crucial importance.

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KEY TERMS

Agent Communication Language (ACL): Language used by agents in exchange of messages and defining common syntax for cooperation between heterogeneous agents.

Agent Negotiation: A model of communication among agents that may have conflicting interests but tries to find a compromise solution so that agents mutually benefit from reaching agreement.

Cooperative Multi-Agent Interactions: Interactions among agents that share common goals in order to achieve improved collective performance.

Intelligent Software Agent: An encapsulated computer system that is situated in some environment and that is capable of flexible, autonomous action in that environment in order to meet its design objectives (Wooldridge & Jennings, 1995).

Middle-Agents: Agents that facilitate cooperation among other agents and typically connect service providers with service requestors.

Multi-Agent System (MAS): A software system composed of several agents that interact in order to find solutions of complex problems.

Self-Interested Multi-Agent Interactions: Interactions among agents that do not share common goals. These interactions often include competition and rely on negotiation.

Intelligent User Preference Mining

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INTRODUCTION

A business-to-consumer environment can be developed through software agents (Guan, Zhu, & Maung, 2004; Maes, 1994; Nwana & Ndumu, 1996; Wang, Guan, & Chan, 2002) to satisfy the needs of consumers patronizing online e-commerce or m-commerce stores. This includes intelligent filtering services (Chanan & Yadav, 2000) and product brokering services to understand user's needs better before alerting users of suitable products according to their preference.

We present an approach to capture individual user response towards product attributes including nonquantifiable responses. The proposed solution can capture the user's specific preference and recommend a list of products from the product database. With the proposed approach, the system can handle any unaccounted attribute that is undefined in the system. The system is able to cater to any unaccounted attribute through a general descriptions field found in most product databases. In addition, the system can adapt to changes in user's preference.

BACKGROUND

In e-commerce activities, consumers are confused by the large number of options and varieties of goods available. There is a need to provide on top of the existing filtering and search services (Bierwirth, 2000) an effective piece of software in the form of a product brokering agent to understand their needs and help them in selecting products.

Definitions

A user's choice in selecting a preferred product is often influenced by the product attributes ranging from price to brand name. This research will classify attributes as accounted, unaccounted, and detected. The same attributes may also be classified as quantifiable or nonquantifiable. *Accounted attributes* are attributes that the system is specially customized to handle. A system is designed to capture the user's choice in terms of price and brand name, making them accounted attributes. *Unaccounted attributes* are not predefined in the system ontology. The system does not know whether an unaccounted attribute represents a product feature. Such attributes merely appear in the product descriptions field of the database. The system will attempt to identify unaccounted attributes that affect the user's preference and consider them as *detected attributes*. Thus, detected attributes are unaccounted attributes that are detected to be crucial in affecting the user's preference.

Quantifiable attributes contain specific numeric values (e.g., memory size) and their values are well defined. Nonquantifiable attributes on the other hand do not have any logical or numeric values, and their valuation could differ from user to user (e.g., brand name). The proposed system defines price and quality of a product in the ontology and considers them to be quantifiable, accounted attributes.

Related Work

One of the research goals among related work is to understand a user's needs before recommending products through the use of product brokering services. Due to the difference in complexity, different approaches were proposed to handle quantifiable and nonquantifiable attributes. One approach to handling quantifiable attributes is to compile these attributes and assign weights representing their relative importance to the user (Guan, Ngoo, & Zhu, 2002; Sheth & Maes, 1993; Zhu & Guan, 2001). The weights are adjusted to reflect the user's preference.

Much research aimed at creating an interface to understand user preference in the context of nonquantifiable attributes. This represents a more complex problem as attributes are highly subjective with no discrete metric to measure their values. Different users give different values to a particular attribute. MARI (Multi-Attribute Resource Intermediary) (MARI, 2007) proposed a "word-of-mouth" approach to solving this problem. The project split up users into general groups and estimated their preference to a specific set of attributes through the group each user belongs to. Another approach to handling nonquantifiable attributes involves requesting the user for preferred attributes. Shearin and Liberman (2001) provided a learning tool for users to explore their preferences before requesting them to suggest desirable attributes.

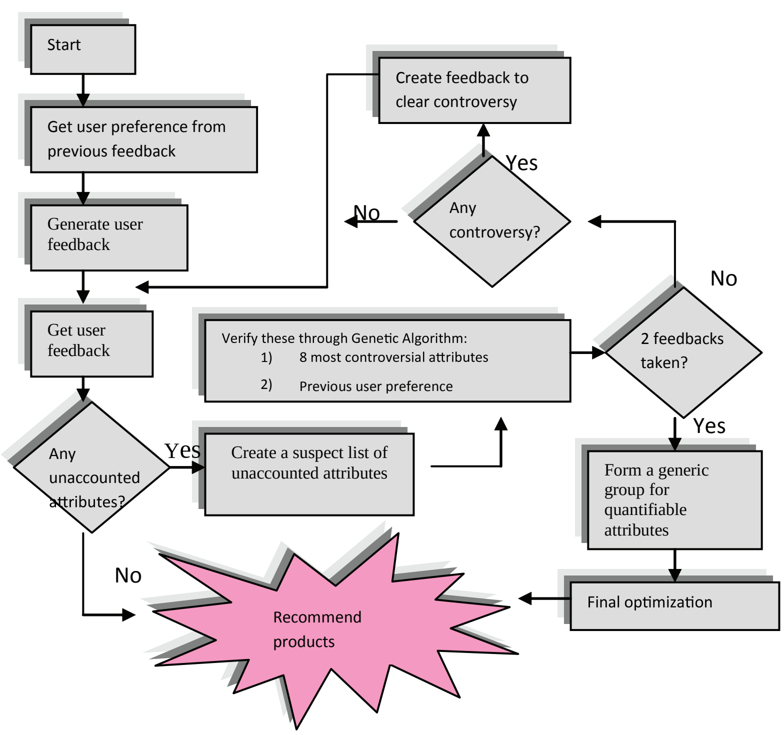
The problems in related work lie in the handling of nonquantifiable attributes, as the approaches are too general. Most work so far only attempted to catch user preference through generalization and stereotyping instead of understanding specific user needs. Another problem is that most works are only able to handle a specific set of attributes. The attributes to be handled are hard-coded into the system design, and the consequence is that it is not able to handle attributes that are unaccounted. However, the list of product attributes is often large. The approach used in related research may not be able to cover all the attributes, as they need to classify them into the ontology.

DESCRIPTION OF INTELLIGENT USER PREFERENCE DETECTION

The proposed approach attempts to capture user preference based on two quantifiable accounted attributes, price and quality. It learns incrementally any unaccounted attribute that affects a user's preference. If any unaccounted attribute is suspected, the system comes up with a list of candidate attributes and verifies their importance through a genetic algorithm (Haupt & Haupt, 1998). Thus, attributes that were unaccounted for previously will be considered. The unaccounted attributes are derived from the general descriptions field of a product. The approach is therefore adaptive in nature, as the system is not restricted by the attributes it is designed to cater to.

The overall procedure is shown in Figure 1. The system first retrieves any captured information regarding the user from previous feedback and generates a list of products from the product database for the user to rank and investigates the presence of any unac-

Figure 1. System flowchart diagram



counted attribute affecting the user's preference. The system then compiles a list of possible attributes that are unaccounted for by analyzing the user feedback and rank these attributes according to their suspicion levels. The most suspicious attributes and any information captured from previous feedback are then verified using a genetic algorithm. If two cycles of feedback are completed, the system attempts to generalize any quantifiable attributes to form a generic group of attributes. The system finally optimizes the information collected by the genetic algorithm and recommends a list of products from the product database to the user according to the preference captured.

Tangible Score

In our application, we shall consider two quantifiable attributes, price and quality, as the basis in deriving the tangible score. The effect of these two attributes is always accounted for. The equation to derive this score is as shown in Equations 1-3.

$$\text{Score}_{\text{PriceCompetitive}} = \text{PrefWeight} * (\text{MaxPrice} - \text{Price}) / \text{MaxPrice} \tag{1}$$

$$\text{Score}_{\text{Quality}} = (1.0\text{-PrefWeight}) * \text{Quality} \tag{2}$$

Equation 1 measures the price competitiveness of the product. PrefWeight is the weight or importance the user places on price competitiveness as compared to quality with values ranging from 0 to 1.0. A value of 1.0 indicates that 100% of the user's preference is based on price competitiveness. A product with a price close to the most expensive product will have a low score in terms of price competitiveness and vice versa.

Equation 2 measures the score given to quality. The quality attribute measures the quality of the product and takes a value ranging from 0.0 to 1.0. The value of "1.0 – PrefWeight" measures the importance of quality to the user. The final score given to tangible attributes are computed by adding Equations 1 and 2 as shown in Equation 3 below.

$$\text{TangibleScore} = \text{Score}_{\text{PriceCompetitive}} + \text{Score}_{\text{Quality}} \tag{3}$$

Modification Score for Detected Attributes

The modification score is the score assigned to all detected attributes by the system. These detected attributes were previously unaccounted for but had been detected by the system to be an attribute in the user's preference. These include all other attributes

$$\text{Modificati on Score} = \sum_{i=1}^{NoOfAttrib\ utes} (K_i - 1) * TangibleSc\ ore \tag{4}$$

besides price and quality. As these attributes may not have a quantifiable value, the score is taken as a factor of the TangibleScore derived earlier. The modification score is shown in Equation 4 whereby the modification factor K is introduced.

The values of each modification factor K ranges between 0.0 and 2.0. A value of K is assigned for each newly detected attribute. The modification factor K takes a value of 1.0 that gives a modification score of 0 when the detected attribute does not affect the user's choice. When K<1.0, there is a negative or penalty score for the particular attribute when the user has negative interest. When K >1.0, we have a bonus score to the attributes when the user has positive preference towards certain attributes. The final score for the product is as shown in Equation 5 as the sum of tangible and modification scores.

$$\text{Final Score} = \text{Tangible Score} + \text{Modification Score} \tag{5}$$

A Ranking System for User Feedback

As shown in Equations 1 and 2 earlier, there is a need to capture user preference in terms of the PrefWeight in Equation 1 and the various modification factor K in Equation 4. The system will request the user to rank a list of products. The system makes use of this ranked list to assess a best value for PrefWeight in Equations 1 and 2. In case when no unaccounted attributes affect the user's feedback, the agents will be evolved and optimized along the PrefWeight gradient.

Fitness of Agents

The fitness of each agent depends on the similarity between the agent's ranking of the product and the ranking made by the user. It reflects the fitness of agents in capturing the user's preference.

Unaccounted Attribute Detection

To demonstrate the system's ability to detect unaccounted attribute, the ontology will contain only price and quality while all other attributes are unaccounted and remain to be detected, if they are relevant to the user. These unaccounted attributes include nonquantifiable attributes that are subjective in nature. The unaccounted attributes can be retrieved by analyzing the descriptions field of a product database thus allowing new attributes to be included without the need of change in system design.

The system first goes through a detection stage where it comes up with a list of attributes that affect the user's preference. These attributes are considered as unaccounted attributes as the system has not accounted for them during this stage. A *confidence score* is assigned to each attribute according to the possibility of it being the dominant attribute influencing the user's preference.

The system will request the user to rank a list of products after that it analyzes the feedback according to the process as shown in Figure 2. The agents then attempt to explain the ranking by optimizing the PriceWeight and various K values. The fittest agent will give each product a score.

The system loops through the 10 products that are ranked by the user and compares the score given to products. If the user ranks a product higher than another, this product should have a higher score than a lower ranked product. However, if the agent awards a higher score to a product ranked lower than another, the product is deemed to contain an unaccounted attribute causing an illogical ranking. This process is able to identify all products containing positive unaccounted attributes that the user has preference for.

The next step is to identify the unaccounted attributes inside these products that cause such illogical rankings. The product descriptions for these products with illogical rankings are analyzed and tokenized. Each word in the product descriptions field is considered as a possible unaccounted attribute affecting the user's preference. Each token is considered as a possible attribute affecting the user's taste. The system will analyze the situation and modify the confidence score according to the cases as shown.

1. The token appears in other products and shows no illogical ranking: deduction of points.
2. The token appears in other products and shows illogical ranking: addition of points.

Figure 3. Chromosome encoding

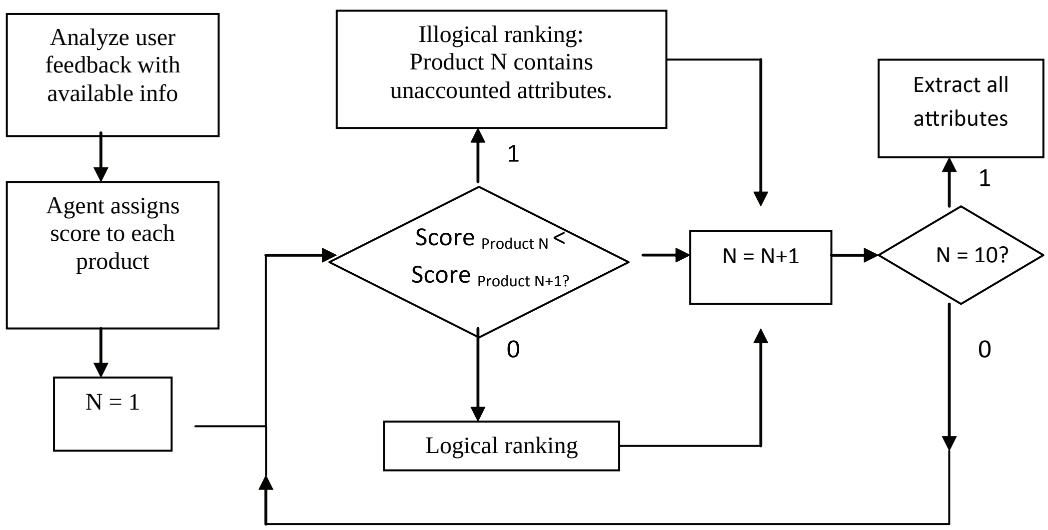
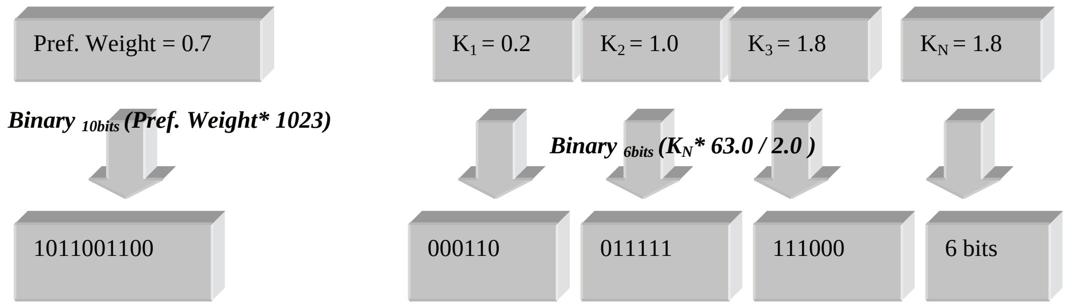


Figure 2. Process identifying products with illogical rankings



Confirmation of Attributes

The attributes captured in previous feedbacks may be relevant in the current feedback as the user may choose to provide more than one set of feedback. The system thus makes a conjecture that the user's preference is influenced by certain attributes affecting him in previous feedbacks if available and eight other new attributes with the highest confidence score. The effect of these attributes on the user's preference is verified next.

Each agent in the system will estimate the user's preference by randomly assigning a modification factor ("K" value) for each of the eight attributes with high confidence score. Attributes identified to be positive are given K values greater than 1.0 while negative attributes would have K values less than 1.0. The PrefWeight and K values are optimized by a genetic algorithm to improve the fitness level of the agents.

Optimization Using Genetic Algorithm

The status of detected attributes perceived by the agents and the most suspicious attributes will be verified here. The PrefWeight and various K values will be optimized to produce maximum agent fitness. As this is a multidimensional problem (Osyczka, 2001) with each new K value introducing a new dimension, we use a genetic algorithm to convert the attributes into binary strings. The agents are evolved under the genetic algorithm to optimize the fitness of each agent. The attributes of each agent are converted into a binary string as shown in Figure 3, and each bit represents a chromosome. In the design, 10 bits are used to represent the PrefWeight while 5 bits are used to represent the various K values.

Incremental Detection System

The system takes an incremental detection approach in understanding user preference, and the results show success in analyzing complex user preference. The system acknowledges that not all vital attributes may be captured within one set of feedback and thus considers refinement of the results of previous sets. The attributes that affect a user's preference in one feedback become the prime candidates in the next set of feedback. In this way, the attributes that are detected are preserved and verified while new unaccounted attributes are being detected allowing the agents to learn incrementally about the attributes that affect the user's preference. However, some of the information captured by the system may be no longer valid as the number of feedback cycles increase. This creates a problem in the incremental detection system, as the information may not be relevant. To solve this problem, the system checks the validity of past attributes affecting the user's preference and delete attributes that are no longer relevant in the current feedback. Each set of feedback contains two feedback cycles.

Both feedback cycles attempt to detect the presence of any unaccounted attributes. In addition, the first cycle will delete any attributes that are passed from previous feedbacks and no longer relevant. These attributes should have a K value of 1.0 after we apply the genetic algorithm. Any controversial attributes detected by the first cycle will be clarified under the second feedback cycle.

IMPLEMENTATION OF INTELLIGENT USER PREFERENCE SYSTEM

A prototype was created to simulate the product broker. An independent program is written and run in the background to simulate the user. This program is used to provide feedback to the system and ranks the list of products on behalf of a simulated user who is affected by price and quality as well as a list of unaccounted attributes. The system is also affected by some generic groups of quantifiable attributes. It was observed that the performance of the system is closely related to the complexity of the problem. More complex problems tend to have lower overall performance. However, this is alleviated by providing multiple sets of feedback. The system was able to detect those attributes affecting the user's preference, and in the cases tested, the gap in performance was negligible. The system also demonstrated its ability to adapt to changes in user preference. This is important when multiple sets of feedback are involved as the user's preference may vary between feedback cycles.

FUTURE TRENDS

The current system generated user feedbacks to clarify any doubts on suspicious attributes. However, more than half of the feedbacks were generated in random to increase the chances of detecting new attributes. These random feedbacks were generated with products of different brand names having an equal chance of being selected to add to the variety of the products used for feedbacks. This could be improved by generating feedbacks to test certain popular attributes to increase the detection capabilities.

CONCLUSION

We have presented a solution in handling unaccounted attributes without the need of change in the ontology or system design. The results showed that the system is indeed capable of capturing the user's preferences even when unknown attributes were present. The system is also able to handle the presence of multiple unaccounted attributes and classify quantifiable attributes into a generic group. Given the possibility that unaccounted attributes could remain undetected during the process of mining, it could happen that a list of products recommended to the user has none matched against her preference or worse, that the user who makes a purchase based on available information and subsequently he discovers that there were other products better meeting his needs. How to ameliorate such a situation is a challenging task, and it is on our future research agenda.

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KEY TERMS

Accounted Attribute: A quality, feature, or characteristic that is listed in product specifications of a specific product.

Attribute: A quality, feature, or characteristic that some product has.

E-Commerce: Consists primarily of the distributing, buying, selling, marketing, and servicing of products or services over electronic systems such as the Internet and other computer networks.

Genetic Algorithms: Search technique used in computer science to find approximate solutions to optimization and search problems. Genetic algorithms are a particular class of evolutionary algorithm that uses techniques inspired by evolutionary biology such as inheritance, mutation, natural selection, and recombination (or crossover).

M-Commerce: M-commerce, or mobile commerce, stands for electronic commerce made through mobile devices.

Ontology: Studies being or existence and their basic categories and relationships, to determine what entities and what types of entities exist.

Product Brokering: A broker is a party that mediates between a buyer and a seller.

Software Agent: An abstraction, a program that describes software that acts for a user or other program in a relationship of agency.

Tokenize: The process of converting a sequence of characters into a sequence of tokens or symbols.

Interactive Television Accessibility and Usability

I

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INTRODUCTION

Today, there are more than 70 million people aged 60 and above in the European Union.

According to Eurostat, over the next 15 years, the population aged 65 and over will increase by 22%. Many of these citizens will experience dexterity, cognitive, hearing, and sight problems in later life. This means that more than one in seven adults in Europe will have hearing problems. Some 7.4 million people already suffering uncorrectable sight loss will add to the number of European citizens experiencing some form of sensory impairment (Stallard, 2003).

Interactive digital television (iTV) is evolving into an enhanced entertainment and information service. There are various degrees of interactivity in digital television: pressing a simple remote control button, sending information back and forth, or servicing providers by means of a return path. If they are to be adopted, interactive facilities need to be usable by viewers, even because, as Jacob Neilsen points out, "increased accessibility for users with disabilities almost invariably leads directly to improved usability for all users" (Slatin & Rush, 2003). Unfortunately, interactive digital television design appears to have been based on the conceptual models of keyboard-based systems, but their users, skills, goals and attitude of interaction differ. The TV audience is more diverse, some having no prior computer experience. It must be realised that iTV is not a PC and therefore cannot be treated as such.

As far as usabiltity for interactive television, a literature review shows that the approach followed by the majority of scientific publications is also mainly PC-centric and in the majority of cases implicitly focused on the work environment. Differences between the two environments and strategies for resolution of the issues involved have been noted by academics and practitioners (Chorianopoulos, 2003). Unfortunately, traditional usability engineering techniques focus on and have been developed to measure work-related goals like successful task completion, efficiency and error rate, parameters usually positively correlated with user satisfaction. In a usability test of three video interfaces, users preferred the interface that required more time, clicks, and had the highest error rate. According to Drucker, Glatzer, De Mar, and Wong (2002), 'While the performance based on time to task completion and number of clicks was the worst in the novel interface, the user satisfaction was significantly better with this interface.' Users made their choice on the basis of how amusing and relaxing an interface was.

The emergence of interactive television requires a fresh view of current paradigms. New usability evalutation techniques for interactive television must be designed and experimented with. This brings new challenges for television programme producers who have no strong tradition of minutely analysing viewer interaction with television, preferring instead to rely on survey methods such as diaries, questionnaires, focus groups, or automated monitoring to discover viewers' attitudes (Gauntlett & Hill, 1999). Several evaluation techniques may be applicable to digital television, including analytical approaches such as heuristic evaluation (Nielsen, 1993), consisting of having a small set of evaluators examine the interface and judge its compliance with recognised usability principles («heuristics»). Building on growing evidence from studies reported in the literature, it is becoming possible to derive TV-specific heuristics. Nonetheless, nothing has yet been definitively established. Here we concentrate on empirical evaluation, based on observation and interview sessions with viewers.

According to Pemberton and Griffiths (n.d.), there are a number of areas that distinguish the use of personal computers from the use of iTV. These differences suggest that evaluating digital television might require an approach differing from that for desktop applications. They also suggest that results reliable for desktop applications may need handling with more caution in an interactive television context. According to Gauntlett and Hill (1999) and Masthoff (2002), the major differences are:

- **Physical characteristics of interaction:** Viewers watch television at some distance from the screen, typically in an environment oriented toward relaxation and comfort. Resolution is much lower than computer display screens, and color behaves differently. Detailed information is presented via audio. All interactions are carried out via a handset (combined in some cases with a keyboard).
- **Multiple information channels are mediated via the same device:** There is conflict between watching the broadcast stream and manipulation of any interactive components; viewers must divide their cognitive resources between watching and interacting, and this may be reflected in design through allocation of screen 'real-estate.'
- **The optional status of television viewing:** Television tends to mean leisure and entertainment rather than work or other serious pursuits. Thus, the task-oriented approach most often adopted by usability evaluators may be inappropriate.
- **Social characteristics of interaction:** The domestic setting in which TV is utilised is complex, and its numerous facets make evaluation difficult.

BACKGROUND

Abilities may vary from person to person, and, in the course of time, in different people with the same type of disability. People may have combinations of different disabilities and combinations of varying severity levels. The number and severity of limitations tend to increase as people age and may include changes in vision, hearing, memory, or motor function. Many accessibility solutions described in this document contribute to "universal design" (also called "design for all") by benefiting nondisabled users as well as people with disabilities. In this article, three different disabilities will be focused on: sight, visual impairment, and dyslexia.

What a person with specific impairment experiences is often an impediment due to overloading input on different abilities at the same time. A typical case is a prelingual deaf person. Although one might think the only problem might be one of hearing, possibly to be overcome with captions or a cochlear implant, the handicap is much more severe than expected. Having acquired reading and speaking skills as a deaf person, he can generally recognise words that have been taught to him during speech training. All other terms will have to be inferred from context. In other words, in some forms of disability, the main problem lies in integrating different inputs into a comprehensible piece of information without being overwhelmed by the task.

Dyslexia

Approximately 4% of the population is severely dyslexic

A further 6% have mild to moderate problems connected with dyslexia

(Tiresias Organization, http://www.tiresias.org/guidelines/dyslexia.htm)

Developmental dyslexia is a condition or learning disability causing difficulty in reading and writing and present despite normal intellectual, cognitive, and sensory development. People are often identified as dyslexic when their reading or writing problems cannot be explained by a lack of intellectual ability, inadequate instruction, or sensory problems such as poor eyesight.

Dyslexia is not limited to reversing the order of letters in reading or writing. Nor is it a visual perception deficit involving reading letters or words backwards or upside down, as often implied in popular culture.

The most frequent symptoms of dyslexia are:

- Difficulty in learning through language alone
- Difficulty in processing information sequentially

Dyslexics are visual thinkers and use all their senses. As they tend to think in images, they find it difficult at times to understand letters, symbols, or written words.

A dyslexic person has difficulty reading the words in a line and starting again on the next line and frequently skips whole words or whole lines. She might also add extra syllables to words due to difficulty in reading from left to right. Dyslexics tend to favour inferring processes rather than decoding ones. Although this is a valid instrument in itself, it might be a source of error. They tend to start decoding the first part of the word and then “make up” the rest of it (Shaywitz & Shaywitz, 2001).

Deafness

There are more than 80 million Europeans with hearing loss

(*Hear It* Organization, *http://www.hear-it.org/page.dsp?page=2569*)

There are several types of deafness, some of them overlapping:

- **Unilateral:** The inability to perceive sounds with one ear.
- **Prelingual:** Deafness acquired before normal speech developed, not usually allowing normal development of speaking skills.
- **Perilingual:** Deafness acquired while the first language was still being learned, often causing incomplete development of speaking skills.
- **Postlingual:** Deafness acquired after speaking skills had completely developed
- **Partial:** A decrease in one’s ability to perceive sounds without causing total hearing loss.
- **Profound:** A severe decrease in one’s ability to perceive sounds, rendering him completely unable to hear sounds of normal (or any) intensity.

An individual’s hearing loss is assessed using audiometry, which measures loss in decibels (dB) at different frequencies. The different levels of hearing loss are classified as:

- **MILD 16–35 dB.** May have difficulty hearing faint or distant speech, losing up to 10% of the speech signal when the speaker is at a distance greater than three feet or if the environment is noisy.
- **Moderate 36–50 dB.** Understands conversational speech at a distance of 3–5 feet. Amplification may enable the listener to hear and discriminate all sounds. Without amplification, 50% to 100% of the speech signal may be lost. Speech may be affected unless optimally amplified.
- **Moderate/Severe 51-70 dB.** Conversation must be very loud to be heard without amplification. A 55dB loss can mean 100% of the speech signal is lost.
- **Severe 71-90 dB.** If loss is prelingual, spoken language and speech may not develop spontaneously or be severely delayed in absence of modification or intervention.
- **Profound 91 dB or greater.** Aware of vibrations more than tonal pattern. Many rely on vision rather than hearing as the primary avenue for communication and learning.

The above degrees of deafness affect speaking and reading skills in different ways. In mild hearing loss, there are no comprehension problems, but omission or alteration of certain phonemes; for example, /b/, can be confused with /p/. In moderate hearing loss, damage involves both significants (the letters in words) and their meaning. In severe or profound loss, there is no perception of the spoken word.

Visual Disabilities

In Europe there are 2.7 million totally blind people, 12.8 million with low vision and 15.5 million with visual impairment.

(World Health Organization, http://www.who.int/mediacentre/factsheets/fs282/en/index.html)

There are many types of low vision, for instance poor acuity (vision that is not sharp), tunnel vision (seeing only the middle of the visual field), central field loss (seeing only the edges of the visual field) and clouded vision. Visual limitations tend to increase as people age. An ever-increasing number of people are at risk of visual impairment as populations grow and older age groups predominate.

Important Differences between Television and the Web

When working for iTV, there are some areas that designers accustomed to creating normal Web sites should take into account (Johansson, 2005):

1. **Screen size:** Television screens are often larger than computer screens, but their resolution is lower.
2. **Color and contrast:** Limited to a smaller range of colors on a TV. Fully saturated colors and some color combinations tend to bleed. The picture is generally much fuzzier than the one on a computer screen.
3. **Fonts and readability:** Because of greater viewing distance, the designer needs to use larger text on TV than on a computer screen. You will also want to increase line height a bit and add a little letter spacing to avoid individual letters bleeding into each other.
4. **Viewing distance:** The normal viewing distance is much greater for television than for computers, which makes the image reaching the eye smaller. Designers need to make text and important graphics larger than if the application were viewed on a computer screen.
5. **Navigation:** The main navigation tool for iTV is the remote control.
6. **Sound:** Web sites rarely use sound, while television uses it continuously. Speech therefore needs to be made available to people who cannot hear.

MAIN FOCUS OF THE ARTICLE

This document is based on an iTV usability test carried out on the following small group of disabled people:

1. A dyslexic child
2. A severe hearing-impaired teenager with bilateral neurosensorial hypoacusia having a cochlear implant.
3. A moderately-severe teenager with bilateral neurosensorial hypoacusia having a cochlear implant.
4. A low-vision teenager

The number of subjects was reduced to the minimum, as suggested by Nielsen (2000) when he states:

as you add more and more users, you learn less and less *because you will keep seeing the same things again and again. There is no real need to keep observing the same thing multiple times, and you will be very motivated to go back to the drawing board and redesign the site to eliminate the usability problems. …After the fifth user, you are wasting your time by observing the same findings repeatedly but not learning much new.*

The usability test was organised as follows:

Step 1: Planning the usability test

It was decided to have one subject (the visually impaired one) add her comments while performing each task ('think aloud') and the other three after finishing all tasks (retrospectively). The first subject was also asked to complete the questionnaire retrospectively. When using the 'think aloud' method, participants report on incidents as soon as they happen. When using the retrospective approach, participants perform all tasks uninterruptedly, and then report any observations (critical incidents). Studies have reported no significant difference between the 'think aloud' vs. retrospective approaches in terms of the number of useful incident reports given by participants. The test was set to be a task-oriented activity, where users had to follow precise instructions and interact with the additional services of interactive television.

Step 2: Defining the audience and goals of usability testing

The goals of usability testing should be focused on determining whether the interface is usable and whether the intended audience, and anyone else who might come into contact with it, can use it. The study set reasonable goals to be achieved with a limited amount of time and subjects.

Step 3: Choosing subjects and evaluators

The subjects chosen for this usability test were volunteers in contact with a local support center for young people with impairments. They were:

- **1 visually impaired**
- **2 hearing impaired**
- **1 reading impaired (dyslexic)**

The evaluators were a psychologist working in a public center for disabled people and a multimedia consultant. The psychologist acted as the facilitator, giving feedback and helping subjects carry out their tasks. According to Spool (2005), a good facilitator knows how to draw out exactly the right information from the participant without giving away the store. He knows how to use the very limited test time to focus on those elements that are most important for the team. The other member of the team stood apart, taking notes without interfering with the experiment. Both evaluators took notes on verbal and nonverbal messages conveyed by subjects.

Step 4: Providing a pretest questionnaire

An initial questionnaire was administered to subjects in order to gather useful information about them before the test. In particular, the pretest questionnaire collected additional background information about their familiarity with digital television, computers, and video games. This additional information proved valuable in analysing and interpreting data.

Step 5: Providing brief instructions (the test script)

During the test, participants had to follow a printed task sheet. The copy for the visually impaired was printed with larger fonts. The task was designed to be:

- **Short.** Time is precious during usability testing.
- **Specific.** The wording of the scenario should be unambiguous and have a specific goal.
- **Realistic.** The scenario should be typical of the activities that an average user would do on his own.
- **In the user's language and related to her context.** The scenario should explain the task the same way users would.

Step 6: Set the test

In order to facilitate the test, it is important for evaluators to:

- Keep participants focused on the task. People will tend to wander off, but it is important to keep them focused.
- Take shorthand notes or (even better) get someone else to take notes, focusing on really important/interesting behaviour.
- Let the participant make mistakes. This will reveal aspects of the interface that may need improvement.
- Answer questions with questions, forcing the user to give more feedback.
- Do not tell the participant what to do, but you can suggest and discuss design solutions that might solve a usability issue.
- Do not explain the interface. Doing so prevents you from getting their unbiased perception of the site.

Step 7: Post-test questionnaire

At the end of the test, participants had to fill in a questionnaire about their experience.The purpose of the post-test questionnaire is to record the participant's perception of test difficulty and to gather relevant comments where applicable. The questionnaire should reflect the participant's overall perception of the system's usability and specific perception related to usability concerns.

Step 8: Process the results

After the session was over and the participant had left, evaluators completed their notes, writing down all the interesting and important behaviour the participant exhibited during the session.

Individual Pathologies and Test Responses

The following are the observation sheets for each subject and a description of their disability.

Observation sheet #1
C.P. 16 years old
Diagnosis: severe bilateral neurosensorial hypoacusia, with language impairment, use of cochlear implantation and oral comprehension through lip reading.
User's first experience with ITV

Test Time: 18 minutes
Tasks 1-9
First Part

Task sheet for testing the accessibility of digital television

Tasks to carry out

First Part

1. Press button #2 on the remote in order to select channel #2
2. Press the red button on the remote to load interactive elements
3. Once they are loaded, choose the “NEWS” menu
4. Choose the second piece of news among those listed using the arrows
5. Press on OK to read the news
6. Read the news aloud in all its parts (it will take more than one page)
7. Go back to the initial menu, pressing EXIT
8. Now choose the option SURVEY
9. Cast your vote on one of the options presented

Second Part

10. Press button #5
11. Load the interactive options by pressing the red button
12. Choose the menu item GAMES
13. Choose the first game on the list
14. Read the game instructions
15. Play the game
16. When you finish, press the EXIT button

Third Part

17. Press button #7
18. Load the interactive options by pressing the red button
19. Choose NEWS from the menu
20. Scroll down the list and choose one that you find interesting
21. Read the news aloud
22. When you finish, press the EXIT button
23. Turn off the television and the decoder

Observations

Good dexterity with the remote and good knowledge of how to use remote buttons and functions.

In order to read the text on the screen, he has to get closer to the TV, less than a meter away.

He experiences some difficulty in reading due to scarse visibility and sharpness, due to low color or brightness contrast in relation to the background (for example, white or yellow text on a green background), text on a decorated background or the use of too narrow a font, with too little space between letters.

Difficulty in understanding the news text, written in narrative form, without having the most important parts highlighted and the structure clearly marked. Subject not familiar with some terms used in the news.

Tasks 10-16

Second Part

Observations

Game instructions unintelligeable to the subject. The way they are described forces the hearing-impaired viewer to try to summarise complex content in order to discover the relevant steps to follow. The task of interpreting the instructions too difficult without the help of the facilitator.

Third Part
Tasks 17 –23

Observations
Reading is difficult due to low contrast with the background and to the length of narrative texts.

Difficulty in finding information on the screen was due to:

a. Too much input
b. Inattention to visual stimuli at the edges of the central area

Drop-down menus not easy to navigate.

Notes
Many problems are due to the subject's limited acquired vocabulary, to having her read some texts aloud and to decoding long and complex texts. Problems in handling too many pieces of information at once.

Observation Sheet #2:
N.P. 15 years old
Diagnosis: Bilateral neurosensorial hypoacusia, with language impairment, use of cochlear implantation, good oral skills, myopia and astigmatism.

User expert in the use of iTV programs

Test Time: 13 minutes

Tasks 1-9
First Part

Observations
Good dexterity with the remote, good knowledge of buttons and functions.

Some minor problems in reading due to scarse visibility and brightness caused by low contrast.

Tasks 10-16
Second Part

Observations
Some problems in reading due to terms the viewer is not familiar with.

Third Part
Tasks 17 –23

Observations
Reading sometimes difficult due to low contrast.

Notes
Previous experience with digital television and Personal Computer allows the subject to be more autonomous in using the device.

Some problems are due to the subject's limited vocabulary and to his difficulty in summing up long, complex texts. Problems in distinguishing visual elements on the screen.

Observation Sheet #3: P. P. - 8½ years old
Diagnosis: dyslexia, disorthography, discalculia

User's first experience with iTV, but expert in using computer and play station.

Test Time: 35 minuti

Tasks 1-9
First Part

Observations
In order to be able to read, he must be at least 1.5 meters from the TV.

Good dexterity with the remote and good knowledge of its functions

Difficulty in finding the News. Too many visual stimuli and too much to read at the same time.

Difficulty in reading the News due to:

a. The text being too long and complex
b. Taking too long to decode the meaning of the text, with a consequent loss of motivation.

Trying to avoid mistakes, he anticipates some operations, based on his previous experience with play station and computer.

Tasks 10-16
Second Part

Observations
Difficulty in finding information on the screen, due to:

a. Input overload
b. Inattention to stimuli at the edges of the screen.

Difficulty in reading text in capital letters

No problem in playing the game, as similar to some others he's already played.

As he becomes familiar with the functions, to overcome his slow reading, he proceeds by trial and error and tends not to follow the instructions. As a result, he doesn't always reach his goal.

Tasks 17 –23
Third Part

Observations
The subject acts quickly once he understands what to do, but he is very slow in reading instructions.

When the pointer moves over them, hyperlinks not contrasting with the background do not allow the viewer to read the whole text before clicking on the right part.

Tries to compensate for his difficulty in reading by using other perceptions and trial-and- error procedures.

He experiences some difficulty in reading due to scarse visibility and sharpness caused by low colour or brightness contrast with the background or the use of too narrow a font, with little space between letters.

The presence of images does not seem to either help or hinder.

Observation Sheet M.C. #4: 19 years old

Diagnosis: severe bilateral amblyopia due to congenital nystagmus

PC user, little familiarity with ITV

Test Time: 20 minutes
Tasks 1-9

Observations
The subject finds it a bit difficult to read small-sized texts and in general texts that are too bright and flickering.

Yellow text on green background is clearer than white on green background.

In general, she also finds black text on a white background readable, provided that fonts are not too small or letters too crowded.

Tasks 10-16
Second Part

Observations
The subject has no problem in reading text on any part of the screen.

Good readability of dark blue texts on yellow background.

Tasks 17 –23
Third Part

Observations
In this channel, texts are readable enough. News in black against a pale blue background is particularly clear for the subject, thanks even to the large space between lines.

Minor problems in understanding how to use arrows and exit buttons.

Notes
The subject uses the device well and autonomously. Difficulties arise only due to text readability: spacing, font, size, kerning, contrast with background.

SYNTHETIC TABLE OF OBSERVATIONS ACCORDING TO IMPAIRMENT

See Tables 1-3.

FUTURE TRENDS

Industry is aiming for a well-designed, engaging, enhanced television environment with a high return on investment. Many elderly people and visually-impaired people want a minimum amount of confusion within a practical system. This appears to create a conflict of needs between industry and some viewers. Television is traditionally a social, relaxing diversion, so even the general public does not want to work at it. By adopting a user-centered approach and finding out what people want from this media form, the industry's mission can be accomplished.

When it is well-known that a very large percentage of the television audience, especially during the daytime and nonpeak viewing hours,

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Table 1.

General Disability Category	Main Difficulties	Suggestions
Hearing impairment	In reading due to: a) low contrast with background b) little space between letters, words and lines c) texts overly long In finding the required information on the screen due to: a) input overload b) inattention to visuals at the edges of the main central area c) drop-down menus not user friendly In comprehension of information, due to: a) texts being written in an elaborate style b) not having a clearly understandable structure c) not highlighting the most relevant pieces of information	• Increase contrast between text and background • Increase space between letters, words, and lines • Use short texts with a clear structure and highlighted keywords. • Increase contrast and visibility of all elements on the screen (arrows, etc.) • Input reduction • Move all useful information inside the central area of the screen • Introduce arrows to show the sequence of events to be followed • Introduce an interactive glossary for all words not frequently used • Create a demo showing the use of specific functions

Table 2.

General Disability Category	Main difficulties	Suggestions
Dyslexia	1. In order to read, subject needs to be close to the screen (1.5 m) 2. Too many visual and reading stimuli at the same time 3. Difficulty in reading a long, complex text 4. Long time required to decode texts, with consequent reduction in motivation 5. Inattention to stimuli at edges of the screen 6. Links that fade into the background are not entirely visible 7. Low contrast between text and background and little space between letters 8. Images do not specifically contribute to the task	• Introduce the option of automatic text reading • Improve contrast with background and increase spacing and kerning • Use short texts, with a clearly understandanble structure and highlighted keywords • Reduce visual input • Move all items to the central part of the screen • Introduce sequential arrows to show order of steps

Table 3.

General Disability Category	Main difficulties	Suggestions
Low vision	1. Some texts are too small in size or too bright and flickering 2. White texts on green background are not as clear as yellow texts on green background 3. Texts with limited spacing are less readable	• Use the following color combinations: yellow on green; black on pale blue; white on black • Use larger font sizes, wider spacing, and more distance between letters • Use interactive devices to magnify particular texts • Use interactive devices for speech synthesis

is made up of disabled and elderly people, it seems surprising that broadcasters and equipment manufacturers have not given more thought to providing access for this group of people. There is no question, however, that even the healthiest of older people suffers from some impairments, both physical and mental, and it makes good sense for those designing television-based equipment to take them into account if they want to maximise the potential market for digital services such as home shopping.

As stated by the Tiresias Organization, people over 50 years of age naturally have worse vision than when they were younger. Bifocals are common, more light is needed to see fine details, and reflective glare is often more problematic than for younger people. These visual disadvantages apply to the vast majority of ‘ordinary’ people who would not consider themselves as being blind or partially sighted, but it is worth noting that in addition to all these people, there are some 11 million people throughout Europe classified as having ‘low vision,’ defined as an ability to utilise some aspects of visual perception, but with greater dependency on information received from other sources. If the controls and displays on digital TV systems could be designed to suit people who have difficulty in seeing clearly, the market for interactive-type TV services would be greatly expanded at little cost.

Customisation is the opportunity for the user to specify the configuration. An option displaying a system specifically suited to any user’s needs would be useful for everyone. Smart cards could provide a viable method of customising iTV and other systems. Users’ preferences are stored on the smart card, so when it is inserted into the system, it will reconfigure the display appropriately according to the code on the card. Smart cards have advantages over other methods of adapting systems because they can be transferable between systems and require less time and input. In the future, one card may suffice for use on many devices: a multi-service prepayment card (Gill, 1994).

On interactive digital television, smart cards could be used to control text size, content layout, speech output, color combinations, subtitles, audio description, signing, timeouts, reminders and alerts, mode-changing capabilities according to level of expertise, and so forth (Gill, 2002). If people are able to alter the presentation of information, it will render it more accessible. Visual impairment does not lead to a homogeneous population where one solution will benefit everyone, as is evident even from such a small subject sample. Customisation of settings could enable increased accessibility and usability. Further detailed work is thought to be necessary into navigation, the use of columns colors and their combination, and content density. At what point does the screen become too crowded?

CONCLUSION

Guidelines need to be determined, based on scientific principles and specifically for television, enabling designers to meet the needs of people utilising the systems. The results of this usability test have shown weaknesses in interface television design and have permitted the formulation of a series of recommendations for designers of interactive services. These include:

- Items in drop-down menus should also be actived by buttons on the remote, as some users lack the required dexterity to follow prompts on the screen
- Graphic interface displays have to be adjustable to support users' personal preferences, with the option of changing default settings, accessed through a menu subset on the graphic user interface (GUI).
- Display layouts should be simple and in a consistent linear format, in order to avoid input overload in some users
- Strong visual contrast with the background
- Sufficient screen space, enough space between letters, distinguishable breaks between words, the use of double-spacing
- Simple, concise language without abbreviations
- Use of interactive devices to magnify particular texts
- Use of interactive devices for speech synthesis
- Use of short texts, with a clearly-organised structure and highlighted keywords
- Reduction of visual input
- Moving all items to the central part of the screen
- Introduction of arrows to show the sequence of events to be followed.
- Creation of a demo to show the use of specific functions

Disabled people are not a homogeneous population where one solution will benefit all. Customisation of settings could enable increased accessibility and usability.

One final consideration in regard to usability in iTV is that, as a general rule, in the case of digital television, it is required to use a combination of remote controls and on screen displays to provide user interaction. However, users may have difficulties understanding how to scroll and navigate, recognising when an item is highlighted and knowing that it is necessary to press 'OK' to access one's highlighted chosen item. As suggested by Klein, Karger, and Sinclair (2003), due to the fact that the grammar of this type of interaction is based on that of personal computers and is similar to that of mobile phones, people who have never used these products are at a disadvantage in being able to understand how to interact. The result is that some users without experience of personal computers are confused by, or even unable to use, almost every aspect of digital TV.

A solution might be to have a universal design, that is, a design of product and environments to be usable by all people to the greatest extent possible. Unfortunately, in the real world, this ideal is not easily achievable. As a consequence, "universal," in universal design, should not imply one optimal solution for everyone, but rather it should stress the need for inherent flexible, customisable content.

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KEY TERMS

Cochlear Implant: A cochlear implant is an electronic prosthetic device surgically implanted in the inner ear under the skin behind the ear to provide useful sound perception via electrical stimulation of the auditory nerve. Cochlear implants are intended to provide prelingually or postlingually deaf children who obtain limited functional benefit from conventional amplification with improved sound and speech detection and improved auditory perception and speech.

Customization of the Interface: Customization is the ability of the user to specify the configuration. An option displaying a system specifically suited to any user's needs would be universally useful.

Dyslexia: Dyslexia is a neurologically based disorder interfering with the acquisition and processing of language. Varying in severity, it is manifested by difficulties in receptive and expressive language, including phonological processing, reading, writing, spelling, handwriting, and sometimes arithmetic.

Facilitator in a Usability Test: In a usability test, a facilitator is one who encourages the subject's full participation, promoting understanding of the tasks. A good facilitator knows how to draw out exactly the right information from the participant without giving away the store. He knows how to use the very limited test time to focus on those elements that will be most important to the team of evaluators.

Heuristic Evalution of Usability: Heuristic evaluation involves having a small set of evaluators examine the interface and judge its compliance with recognized usability principles ("heuristics"). Experience has shown that different people encounter different usability problems. Therefore, it is possible to significantly improve the effectiveness of the method by involving multiple evaluators.

Prelingual Deafness: This kind of deafness already exists before the person can speak (before the age of three). Profound deafness in childhood affects the development of auditory speech perception, speech production, and language skills.

Retrospective Approach to Test Usability: When using the retrospective approach, participants uninterrupedly perform all tasks and then report any observations (critical incidents).

Usability Test Script: During a usability test, participants follow a printed task sheet. Tasks should be designed to be short, specific, realistic, in the user's language, and related to the user's context.

Think Aloud Method to Test Usability: When using the "think aloud" method in a usability test, participants report on incidents as soon as they happen.

Introduction to Computer Forensics in the Age of Information Warfare

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Police and prosecutors are fashioning a new weapon in their arsenal against criminals: digital evidence. The sigh of hard drives, Internet files and emails as court room evidence is increasingly common.

Michael Coren, CNN Correspondent

INTRODUCTION

The rapid expansion and dramatic advances in information technology in recent years have without question generated tremendous benefits to business and organizations. At the same time, this expansion has created significant, unprecedented risks to organization operations. Computer security has, in turn, become much more important as organizations utilize information systems and security measures to avoid data tampering, fraud, disruptions in critical operations, and inappropriate disclosure of sensitive information. Such use of computer security is essential in minimizing the risk of malicious attacks from individuals and groups. To be effective in ensuring accountability, management and information technology security personnel must be able to evaluate information systems security and offer recommendations for reducing security risks to an acceptable level. To do so, they must possess the appropriate resources, skills, and knowledge.

With the growing perverseness of information systems and the technologies used to support such tools, the growing need to keep the integrity of both the data and the system used to manage that data, will become a major priority. Therefore, it is important for security personnel and management to keep abreast of the issues and trends in information systems, security and the tools and techniques used to secure systems and data.

In order to determine if information safe and systems secured from outside attacks from computer criminals, information systems security assessments must be conducted on a regular and on going basis to insure system security integrity. If there is suspicion of wrongdoing or of misuse of the computer or system, one may employ techniques of procedures of computer forensics. The aim of this chapter is to introduce to the information technology community, a conceptual overview of information computer forensics and investigations and to discuss some of its problems and concerns.

BACKGROUND

Current literature of computer forensics (Nelson, Phillips, Enfinger, & Steurt, 2004; Noblett, Pollitt & Presely, 2000; Weise & Powell, 2005; Whitman & Mattord, 2003) state that the roots of computer forensics start with the first time a system administrator had to figure out how and what a hacker had done to gain unauthorized access to explore the system. This was mainly a matter of discovering the incursion, stopping the incursion if it was still in progress, hunting down the hacker to chastise the attacker, and fixing the problem allowing the unauthorized access to begin with. In the beginning, the classic hackers breaking into computer systems were more interested in how things work than actually being malicious. So, collecting evidence for a hearing was not a process a system administrator needed to worry about. Just plug the hole, and often get back to personal hacking projects.

As computers evolved out of academia to businesses and government, there was more data and resources at risk. Hacker incursions became an issue handled through legal channels (Ferbrache & Sturt, 1997). Also, as computer technology advanced, it became more affordable. This allowed computers to be put not only on each employee's desk of even small business, but in people's homes. More people looking for uses for the computers lead to the increase in supply of programs. More programs made more types of information collected as possible evidence. Evidence derived from computers has been used in court for almost 30 years. This is consistent with the research conducted by Ranum (1997). Initially, judges accepted the evidence as no different from forms of evidence they were already seeing. As computer technology advanced, the accepted similarities to traditional evidential material became ambiguous. In 1976, the U.S. Federal Rules of Evidence was passed to address some of the ambiguities.

A great deal has evolved with computers since 1976. One item of significance is the Internet. This information superhighway has become a major passage of items that fall under legal scrutiny (Nelson et al., 2004). Another item is the amount of data an individual computer can hold. Personal computers of the early 1980's had no internal storage and the removable storage only held 360-kilobytes per diskette. Today, an average personal computer bought for teenager game playing and Internet cruising holds internally 40 billion bytes of data and removable disks hold from 2 million bytes to 2 billion bytes. Large server computers used by academia, government, and business are starting with internal storage averaging 100 billion bytes and have the expandability to use storage devices holding trillions of bytes of data.

This explosion of technology, while providing many times the computing power of the building size computers of the beginning, have made the field of computer forensics exponentially more complicated from the relativity simple tasks of evidence gathering only five years ago.

EXPLORING BRIEF HISTORY OF COMPUTER FORENSICS

Thirty years ago, most people did not image that computers would be an integral part of everyday life. Now computer technical is a common place and a hot bed for criminal activity.

In the 1970s electronic or computer evidence did not hold up in court due to the fact that the fields of computing and computer forensics were new. Yet, computer crimes were being committed by those involved in white collared crimes. According to Nelson (2004), most computers in this era were mainframes, and they were sued by an exclusive realm of highly education and specialized professionals. Professionals who used such computer systems worked in banks, business, and in other markets where the free exchange of many and information was readily available. White-collar fraud began when people in those industries saw a way to make money by manipulating computer data.

One of the most well-known and documented crimes of the mainframe era was the one cent crime. It was common for banks to rack monies in account to the third decimal place or more. Banks used and still use the rounding up method when paying interest. If the interest applied to an account resulted in a fraction of a cent, that fraction would be used in the calculation for the next account until the total resulted in a whole cent. It was assumed that sooner or later every customer would benefit. This method was corrupted on more than one occasion by computer programmers who would open an account for themselves and write program so all the fractional monies went into their accounts. In smaller banks, this could amount to one a few hundred dollars a month. In larger banks with branch offices, the amount reached hundreds of thousands of dollars.

In the 1970s and early 1980s, when computer crimes such as the one half cent crime were being committed, most law enforcement officers did not know enough about computers to ask the right questions or how to preserve electronic or digital evidence for a trial. Many attended the Federal Law Enforcement Training Center programs that were designed to train law enforcement in recovering digital data (Department of Justice, 2002).

As personal computers gained popularity and replaced mainframes as the source of computing, different operating systems emerged. Apple released the Apple 2E in 1982 and then launched the Macintosh in 1984. The disk operating system (DOS) was available in many varieties, including PC DOS, QDOS, DR-DOS, IBM-DOS, and MS-DOS. Forensic tools at the time were simple and most were generated by government agencies such as the Royal Canadian Mounted Police in Ottawa and the Internal Revenue Service. At this time most of the tools were written in C and assembly language and were not available to the general public.

By the mid 1980s, tools such as X Tree Gold appeared. It recognized files types and retrieved lost or deleted files. Norton Disk Edit soon followed and became one of the leading tools in file recovery.

By the early 1990s specialized tools for computer forensic appeared. The International Association of Computer Investigative Specialist (IACIS) introduced training on the software available for forensic investigations, while the IRS created search warrant programs. However, no commercial software for computer forensics was available until ASR Data created Expert Witness for the Macintosh. This particular software was able to recover deleted files and fragments of deleted files.

As computer technology continued to grow, so did the computer forensic software (Nelson et al., 2004; Noblett, Pollitt, & Presely, 2000; Whitman & Mattord, 2003; Weise & Powell, 2005). The introduction of large hard disk posed new problems for investigators. Most DOS-based software does not recognize a hard disk large than 8 GB. Because modern computers have hard disk space of 20 to 80 GB, new forensics software tools are needed. Of the modern software packages available, iLook, a software maintained by the IRS Criminal Investigation Division and is limited only to law enforcement, can analyze and read special data files that are copied to disk. Another popular software package used by commercial and civilian markets is Access Data Forensics Took Kit. This particular software contains everything needed to investigate, secure and analyze computer or digital data.

As we move into the 21st century, we see more sophisticated forms of computer and digital forensics. According to Nolan, O'Sullivan, Branson, and Waits (2005) the first is the ability to intercept a Palm Pilot PDA password either by monitoring the traffic between the PDA and a workstation with a Palm Pilot cradle or by initiating a synchronization update between the password protected PDA and a second PDA. Also, modern computer and digital forensics have the ability to analyze image files to detect if a message is hidden in the file using steganography. Niels Provos and Peter Honeyman at the University of Michigan have developed a process using statistically analysis of a JPEG image to detect if there is a steganographic item stored in the JPEG. Further to add, Neil Johnson, a researcher at George Mason University, is working on being able to identify steganographic items in BMP and GIF images files as well as .wav and .au sound files. As software companies become savvier about computer forensics and investigation, they are publishing more forensic tools to keep pace with the technology.

UNDERSTANDING COMPUTER FORENSICS

Over the years the concept of computer forensics has changed, but at this core the fundamental meaning has yet remained. With the examination of current literature (Ferbrache & Sturt, 1997; Noblett, Pollitt & Presely, 2000; Whitman & Mattord, 2003; Nelson et al., 2004; Nolan et al., 2005; Weise & Powell, 2005) computer forensics involves the preservation, identification, extraction, documentation and interpretation of computer data. It is often more of an art than a science, but as in any discipline, computer forensic specialists follow clear, well-defined methodologies and procedures, and flexibility is expected and encouraged when encountering the unusual. It is unfortunate that computer forensics is sometimes misunderstood as being somehow different from other types of investigations.

According to Nelson, Phillips, Enfinger, and Steuart (2004), computer forensics involves obtaining and analyzing digital information for use as evidence in civil, criminal, or administrative cases. Until recently, legal professional course do not use digital evidence in course because it was not considered tangible evidence. Many court cases in state and federal courts and appellate decisions that were challenged and argued that the United State Supreme Court set precedents for using digital evidence.

Until 1988, investigators needed a separate search warrant to search for and seize computer evidence. The case described in the following summary was one that established a different precedent so that separate search warrants may not be necessary.

It is important to understand that when preparing a search for evidence in a criminal case, many investigators still include the suspect's computer and its components in the search warrant to avoid problem (Nelson et al., 2004). To illustrate this point, the case Commonwealth v. Copenhefer 555 PA 285, 719 A.2d 242, discusses a case where such measures were used. When the detectives summarized the case, he recognized that it established the legal foundation for the seizure and subsequent search of computer used in a crime. The detectives investigated a homicide where the defendant saved incriminating evidence on his business computer. The defendant's attorney appealed to the Supreme course to prevent the prosecution from using the evidence on his computer because the detectives did no obtain a separate search warrant to search the computer. Unfortunately the courts sided with the prosecution (Department of Justice, 2002).

According to the Department of Justice (2002), another case to that examines the legal precedents of computer forensics deals with a case of a kidnapped woman who was found dead, presumably murdered. Initial investigators by the Federal Bureau of investigations (FBI), state police, and local police resulted in the discovery of a series of hidden computer generated notes and instructions, each leading to another. The investigation also produced several possible suspects, include on who owned a nearby bookstore and had a history of hostile encounters with the victim and the husband. In addition to finding physical evidence, investigators also examined a computer used by the victim's husband. They discovered a series of drafts and amendments to the text of a phone call the husband received, a ransom note, a series of other notes, and a detailed plan for kidnapping the victim. On direct appeal, the Supreme Court concluded that the physical evidence, especially the computer forensics evidence, was sufficient to support the conviction of the bookstore owner. From each of the cases described, we can see the legal precedent for the use of computer forensics in the criminal investigation process.

COMPARING DEFINITIONS OF COMPUTER FORENSICS

According to DIBS USA, Inc., computer forensics involves scientifically examining and analyzing data from computer storage media so that the data can be used as evidence in court. Investigating computers typically includes securely collecting the computerized or digital data, examining the suspect data to determine details such as origin and content, presenting the computer or digital information to the courts, and then applying laws to computer and information practice.

For the most part, computer forensics investigates data that can be retrieved from the hard disk or other disks of a computer or computing device. As an archaeologist excavates a site, computer investigators retrieve information form the computer or its components and parts. In contrast, network forensics yields information about ports used to access a computer or ports accessed by a computer to commit a crime. Network forensics uses log files to determine when someone logged on or last used their login ID to access the system. The network forensics investigator tried so determine which Uniform Resource Locator (URL) a user accessed, how they accessed or logged on to the network and from what locations (Noblett, Pollitt, & Presley, 2000).

In order to understand the basics of computer forensics, one must understand the fundamental difference between computer forensics and data recovery. Computer forensics involves scientifically examining and analyzing data from computer storage media so that the data can be used as evidence in court where as data recovery involves recovering information from a computer that the user deleted by mistake or lost during some type of power outage or natural disaster (Nelson et al., 2004; Stair & Reynolds, 2006). To illustrate this point, computer forensics tires to recover data that the user has hidden or deleted in that it can be allowed to be used as evidence in an investigation. The evidence can be incriminating or exculpatory (Department of Justice, 2002; Nelson et al., 2004; Weiss & Powell, 2005). Investigators often examine a computer disk not knowing whether it contains evidence or not. In addition to the hard disk investigation, computer forensic investigators also investigate storage media as well and should they find any data, they piece it together to produce evidence.

According to Nelson et al. (2004) working with computer forensics investigator often involves a collaborative team effort to make computer and network systems secure in an organization. In his discussion, he states that computer investigations and forensics is one of three functions a triad that makes up computing security. In the enterprise network environment, the triad consists of the following parts:

- Vulnerability assessment and risk management
- Network intrusion detection and incident response
- Computing investigation

Based on his research he has concluded that each of the three parts listed, work together as whole to ensure maximum computer and information security.

As we focus the discussion to computer forensics, we will look at the computing investigation portion of the triad. The computing investigations group manages investigations and conducts forensic analysis of systems suspected of containing evidence or compromised material relating to an incident or crime (Department of Justice, 2002). For complex casework, the computing investigations group draws on resources from those involved in vulnerability assessment, risk management, and network intrusion detection and incident response. In addition, it is important to note that the computing investigations group completes all cases investigation and delivers their results to organization management and to the proper law enforcement agencies.

FORMS OF EXAMINATIONS

According to Potaczala (2001) when examining a computer setup, there are two general categories the examination falls into: live/real-time examination or an off-line duplication. Of the types used depends on the situation. When dealing with a network intrusion or a server and network setup, which cannot be made unavailable, live examination is the route taken. If total control can be taken of the computer to be examined, then off-line duplication is the path used.

Potaczala (2001) states that in a live or real-time examination, often the goal is to trace and trap network activities of a system compromise. This involves initially verifying if an intrusion has actually taken place, and if so, determining how and when the intrusion happened. An additional goal, which can prove to be more difficult, is to pinpoint the location of the intruder. The primary difficulty of achieving this goal based in the fact the intruder could be anywhere on the planet. If the intruder is not someone part of the compromised network system, tracking him or her will likely require the cooperation of multiple organizations connected to the Internet as well as navigating any legal barriers as the search for the intruder crosses state and national borders. Due to the legal and human complexities of tracking down a network intruder, often they go untraced unless the network system broken into compromises a nation's security, or the intruder was able to access or destroy items of substantial monetary value (Ranum, 1997). As supporting evidence of an intrusion, the audit log files of each machine compromised or an attempt at compromise, will be examined. Depending on the operating system and the settings on each system, audit log files can vary from being worthless to showing everything that was done on and to a machine.

The other situation when a live examination often takes place is when data of evidential value are stored on a network server, which cannot be taken out of service due to either significant monetary loss or risk to life. Servers falling into this category are ones for large service companies like at banks or the servers of a hospital. In this case, the files suspected of having evidential value are copied from the server to media the investigators can take with them (Potaczala, 2001).

The ideal situation is one where full control of a computer system is handed over to the investigator. The first step before scouring for possible evidence is to make a byte for byte copy of the media being investigated. If the computer has a 20-gigabyte hard drive, a hard drive of at least equivalent size, if not brand, is used to copy the data from the suspect computer. In some cases, software will make a copy of a hard drive by moving the data from the suspect hard drive to burnable CD-ROMs (Potaczala, 2001). The idea behind this is to leave the suspect system as unaltered as possible. This leaves evidential information such as time-date stamps on files, file ownership, and last access information available to the investigator.

Once the copy of the suspect media is made, an array of methods can be used to carry out the examination. The method used often depends on the examiner and the shop employing him or her. However done, the goal of the exam is to search the media's files, unallocated space, unused space, and media formatting for information of probative value.

The Scope of the Field

The scope of computer forensics covers a wide field, which continues to grow as computer technology proliferates its way into every aspect of modern life. The base of computer forensics is recovering data from floppy disks, hard drives, and removable drive cartridges. Recovering data can be just finding it among the active files. Often, it will also include searching the media for files that have been deleted and been listed as unallocated space. When dealing with someone, who is actively attempting to hide information, scouring media space the operating system has registered as free or corrupted.

Within the files found on the media, the scope of what can be found continues to grow. Files early in the discipline were mostly limited to text documents, spreadsheets, and bulky images. Studies conducted by Potaczala (2001), Department of Justice (2002), and Nelson et al. (2004), indicate the next level of computer forensics involves, forensic complications of compression, encryption, password protection, and steganography have been added to the mix. The type of data being found in files has increased also. The operating systems now have configuration files and memory swap files. Now, practically program has its own set of temporary files. Printing is now done mainly via a queue-based system, so there are spool files with possible evidential value. The average web browser has a history file, cookie file, a file of user saved web page addresses, and a cache of images and texts viewed.

On the hardware side recent additions include smart cards with 4 to 64 kilobytes of data space to current USB dongles with up to 64 megabytes of data space. Handheld devices like electronic organizers and personal digital assistants can have megabytes of data. Some currently found includes address books, appointment calendars, documents, e-mail, handwriting, passwords, phone book, text messages, voice messages, and Web browsing associated files. Some even contain Global Positioning System connections leaving behind a trail where the PDA has been (Potaczala, 2001).

Another place evidential data has the possibility of being recovered is on the printers now available. Some have large caches of memory from which documents have the potential of being retrievable. Printers intended for large network setups occasionally also have hard drive type media on board for storage of files queued to print. The printer head, toner cartridge, or ink cartridge may also prove useful as physical evidence to show a printout came from a specific printer.

A branch of computer hardware, which grew out of the need to share data more quickly and the want for centralized servers to store data, is the computer network. As these networks grew and interconnected, the Internet evolved (Ranum, 1997). The interconnection of all these computers opened up new routes for people to attempt to access and destroy the information stored on them. This created the need to have utilities to monitor network traffic and the people to understand what the utilities are showing them. Additional challenges are coming on-line as large wireless networks are being brought into service. In some cases, entire college campuses are being outfitted with a wireless network grid and some metropolitan areas are considering and quietly testing citywide wireless networking to offer to their populations.

The intersecting scope tree is where computers are being used so evidence is left behind. These include auction fraud, child exploitation, computer intrusion, death investigation, domestic violence, counterfeiting, email used for threats, harassment, and stalking, extortion, gambling, identify theft, narcotics, prostitution, and piracy of software, music, images, and video.

FUTURE TRENDS

The items addressed thus far have been for traditional computer setups—desktop workstations and servers with networking interconnecting them. With the miniaturization of electronic components down to near the size of a couple of atoms, the number of computer systems that can become part of an investigation is blossoming.

According to Potaczala (2001), Department of Justice (2002), and Nelson et al. (2004) laptop computers, while not new, are seeing increasing popularity as a supplement to a desktop computer, if not a replacement. They often have the same computing power as a desktop computer and can have just as much storage capacity. Due to the compact format of the computer, opening the console physically has the potential to be more destructive than with desktop models, therefore special hardware adapters are needed to access the hard drive media from a laptop with a desktop computer.

As we look at the rate of our communication technology, the item probably in circulation the most at present is the Personal Digital Assistant (PDA) and the cell phone. A number of companies make these devices. In many cases, the operating system on the PDA and cell phones varies company to company, and in some cases model to model. The type of potential evidence on these devices includes address books, appointment calendars, documents, e-mail, phone books, test messages, and phone messages. Most of these devices can restrict access with a password. Since much of digital media stored on PDA's and cell phones is on a memory chip continually powered by batteries, being able to bypass password restrictions to the device and on individual files is a challenge in progress (Potaczala, 2001).

Another challenge currently making itself a significant speed bump in computer investigations is the amounts of data modern media can hold. Only 5 years ago, the largest hard drive available was 1 gigabyte. Currently, 100-gigabyte hard drives are available to the public. Reports indicate 400-gigabyte hard drives will be available soon (Potaczala, 2001). For removable media, floppy disks of 720-kilobytes or 1.4-megabytes were the bane of computer forensics a few short years ago. Today, the range of removable media goes from a floppy disk able to hold 120-megabytes to removable hard disk cartridges holding 2.2-gigabytes. As DVD-ROM burners become in the price range of the public, a removable media holding currently 4.7-gigabytes and the potential for holding 17-gigabytes is in the near future as collected media for investigation.

With larger media being available, methods to search it quicker for potential evidence will be necessary. The area that provides the possibility for this is parallel processing sets of computers.

Linux provides this capability with an operating system package addition doing clustering. Packages providing this service are the Beowulf project, MOSIX, Legion, Cplant, and PARIS. These parallel processing cluster techniques will allow less expensive and possibly surplus computers, to be used to create the equivalent of a small supercomputer. Besides allowing faster searching of media, it will also assist in guessing passwords at a highly accelerated rate.

CONCLUSION: DEVELOPING COMPUTER FORENSIC RESOURCES

To be a successful computer forensics investigator, one must be familiar with more than one computing platform and environment. In addition, one must familiar with older platforms such as DOS and previous versions of Windows, Linux, Macintosh, as well as current platforms of Window (Nelson et al., 2004).

However, no one can be an expert in every aspect of computing. Likewise, one cannot know everything about the technology one may be investigating. To supplement your knowledge, one should develop and maintain a listing of contacts with computing network, and investigating professionals.

One way to develop your forensics resources kit is to join user groups, associations, and professional organizations. Being active in user group, professional organizations and associations, one can find and learn new strategies, techniques, as well as obscure knowledge of the field, current and noncurrent technologies, as well as the current trends taking place in the field.

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KEYWORDS

Computer Forensics: Involves scientifically examining and analyzing data from computer storage media so that the data can be used as evidence in court. Investigating computers typically includes securely collecting the computerized or digital data, examining the suspect data to determine details such as origin and content, presenting the computer or digital information to the courts, and then applying laws to computer and information practice.

Computer Investigations: The forensics analysis of systems suspected of containing compromised data or evidence relating to an incident or crime.

Data Recovery: Recovering data or information from a computer that he user has deleted.

Incident Response: The practice of detecting a problem, determining its cause, minimizing the damage it causes, resolving the problem, and documenting each step of the response for future reference.

Intrusion Detection: Software that monitors systems and network resources that notifies network security personnel when it sees a possible instruction.

Network Forensics: The capture, recording, and analysis of network events in order to discover the source of security attacks or other problem incidents.

Vulnerability Assessment: The process of identifying technical vulnerabilities in computers and networks as well as weaknesses in policies and practices relating to the operation of these systems.

IT-Enabled Reengineering: Productivity Impacts

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INTRODUCTION

IT-enabled business process reengineering (BPR) is defined as the redesign of business processes by leveraging potential benefits of information technology (IT) and the Internet to gain significant improvements in key areas of firm performance such as service, quality, cost, and speed. In general, IT-enabled BPR comprises replacing manual labor with computer-based automation systems, adopting innovative workflow management systems, streamlining existing operations with the new systems, and digitizing inter-firm communications through the use of emerging exchange standards such as extensible markup language (XML). Firms have been reengineering various business functions for years, ranging from customer relationship management to order fulfillment, and from assembly lines to research and development. Although the very definition of BPR has not changed much, its nature has evolved over time, expanding both the range and depth of services being reengineered.

In this article, we first discuss the effects of IT-enabled BPR on firm productivity by providing both empirical and theoretical evidence from the literature. We then highlight past experiences of several major firms in the United States with the IT-enabled BPR implementations. Finally, we comment on expected future trends in this area.

BACKGROUND

In this section, we provide a detailed survey on two main streams of related research from the literature: the work on the business value of IT and the more specialized literature on the value of IT-enabled BPR implementations.

Business Value of Information Technology

The roots of the literature on the business value of IT can be traced back to 1990's when available data from 1980's failed to show evidence of improved firm productivity from investments in IT in the manufacturing sector (Morrison & Berndt, 1990). This result, later called the "productivity paradox of IT," was found to be even more pronounced in the service sector which had used over 80% of IT products during 1980's (Roach, 1991). Researchers attempted to resolve the paradox by pointing out that the inability to show significant returns may be because of (1) measurement errors of outputs and inputs due to rapid price and quality changes in IT equipment, (2) the time necessary for learning and adjustment, and (3) mismanagement of IT resources by firms due to insufficient expertise to take advantage of using IT in traditional business environments.

Most researchers rejected this paradox by presenting empirical evidence that shows a positive relationship between IT investments and firm productivity (Bharadwaj, Bharadwaj & Konsynski, 1999; Brynjolfsson & Hitt, 1996; Kudyba & Diwan, 2002). Brynjolfsson, Malone, Gurbaxani, and Kambil (1994) showed that the effects of IT on firm productivity are substantially larger when measured over long time periods. This is because long-term returns represent the combined effects of related investments in organizational change.

Not all studies were able to show a clear payoff from IT investments. For example, Barua, Kriebel, and Mukhopadhyay (1995) found that even though IT spending improves intermediate variables of firm performance such as capacity utilization, inventory turnover, or relative price, it does not necessarily lead to improvements in higher-level productivity variables such as Return on Assets (RoA) or market share. Devaraj and Kohli (2003) emphasized the importance of actual usage in driving the impact of IT on firm performance. Consequently, researchers still debate on how the relationship between IT investment and firm productivity can be measured and analyzed (Anderson, Banker, & Ravindran, 2003).

Compared to the general effects of IT investments on productivity, however, much less is known about how value is actually created *within* the firm. In search for an answer, Kohli and Devaraj (2003) recommend that academic studies explicitly report which complementary changes in business practices have accompanied IT investments, including IT-enabled BPR and Enterprise Resource Planning (ERP). Such analyses are believed to isolate and identify the effectiveness of complementary changes leading to IT payoffs.

Payoff from IT-Enabled Business Process Reengineering

The literature on the impact of IT-enabled BPR on productivity is small but growing. Brynjolfsson and Hitt (2000) argued that a significant component of the value of an IT investment is its ability to enable complementary changes in business processes and work practices of firms, which may eventually lead to productivity increases by reducing costs or improving intangible aspects of existing products, such as timeliness, quality, and variety.

Researchers using historical data from banking industry found that the impact of IT investment on bank performance was realized after a certain time lag, and the level of impact depended on the extent to which firms supported their IT investments with organizational redesign (Murnane, Levy, & Autor, 1999). Additionally, Devaraj and Kohli (2000) showed that IT investment contributes to higher revenue after certain time lags, and the effect is more pronounced when combined with Business Process Reengineering initiatives. Bresnahan, Brynjolfsson, and Hitt (2002) studied the effect of three related innovations (information technology, workplace reorganization, and new products and services) on demand for skilled labor. They found firm-level evidence that the demand for skilled labor is positively correlated with all the three innovations. Bertschek and Kaiser (2004) analyzed a cross-sectional data set to investigate the possible relationship between investment in IT, non-IT investment, labor productivity, and workplace reorganization. They found that workplace reorganization induces an increase in labor productivity that is attributable to complementarities between various input factors, including IT and workplace reorganization.

In outlining future research directions in this field, Devaraj and Kohli (2000) commented:

…the literature in BPR implementation is rife with anecdotal evidence and short on rigorous empirical evidence of performance impacts of BPR. There is a definite need to better measure BPR implementations through objective measures, and to relate BPR to organizational performance …

All of the studies briefly surveyed in this section collectively suggest that there are substantial benefits for firms if they can successfully manage the associated structural transformations during Business Process Reengineering implementations. In order to achieve this, firms can employ several established methodologies, including but not limited to, change management, risk management, and knowledge management.

NOTABLE EXPERIENCES WITH IT-ENABLED REENGINEERING

Firms have been implementing numerous IT-enabled reengineering projects since the use of mainframes and personal computers became popular in many industries. While some of these projects are enterprise-wide (e.g., reorganization or focusing on core competencies), others are more restricted in their scope and directed toward a specific business function (e.g., accounting or manufacturing).

Anecdotal business experience shows that the benefits of investments in IT may be more than outweighed by negative interactions with existing organizational practices. Moreover, investments in IT and reengineering cannot succeed in isolation. As a result, the main driver of the most of IT-enabled BPR projects during the 1990's was the belief that firms needed to adopt IT in their business units as part of an organizational change. Therefore, earlier applications of IT-enabled BPR were directed toward significant process changes accompanied by a reduction of personnel costs in labor-intensive operations of firms including accounting, purchasing, and payroll. Such organizational changes cost firms nearly $1.6 trillion in IT-related intangible assets during the 1990s as opposed to a total of $167 billion spending in IT equipment (Brynjolfsson & Yang, 1997). Since then, the use of IT as a supporting tool for BPR projects has affected all functions of firms, gradually displacing traditional labor and capital inputs because of the superior price and performance improvements in IT equipment relative to these inputs.

Most firms have indeed realized benefits from IT-enabled BPR projects, ranging from tangible financial benefits to intangible customer satisfaction and growth sustenance. The CIGNA Corporation, for example, has successfully completed a number of IT-enabled BPR projects and realized savings of $100 million by improving customer service and quality while reducing operating expenses (Caron, Jarvenpaa, & Stoddard, 1994). Similarly, a famous reengineering of the accounts payable process at the Ford Motor Company has increased the speed and accuracy of payments, and certainly improved company relations with its long-term suppliers (Hammer & Champy, 1993).

Nevertheless, not all of the BPR projects are reported to finish successfully. Given the scale of BPR projects, the major organizational changes they entail, and the potential of internal instability, it is fairly reasonable to expect failures in BPR projects. Anecdotal evidence suggests that the payoff from reengineering efforts and IT investments in the United States is mixed at best (Barua, Lee, & Winston, 1996). Bashein, Markus, and Riley (1994) estimated a failure rate of up to 70 percent. Based on interviews with 350 executives from 14 industries, a survey study conducted by the Arthur D. Little consulting company found that 85% of the executives surveyed were dissatisfied to some extent with their reengineering activities (Rock & Yu, 1994). Reengineering experts argue that such poor outcomes are due to (1) expecting too much too soon, (2) a lack of partnership between IT and business, (3) undertaking projects without a complete understanding of costs and benefits, and (4) not exactly knowing how to redesign a set of related business processes.

FUTURE TRENDS

Proliferation of the Internet and diffusion of IT promises a bright future for IT-enabled BPR initiatives. Continuous advances made in these technologies may not only decrease the cost of executing IT-enabled BPR projects, but also increase their success rates. Furthermore, as firms become more digitized and fully connected with the rest of the world, outsourcing may ease the execution of most IT-enabled BPR projects, especially those related with the non-core operations of firms. In this regard, countries including Canada, India, Ireland, and Israel may emerge as the new outsourcing service providers for IT-enabled BPR projects, and contribute to overall productivity increases in the world.

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KEY TERMS

Change Management: A structured managerial approach to guide individuals, teams, and organizations in evolving from a current state to a desired state. Change management processes usually emerge from the needs caused by other enterprise-wide initiatives such as reengineering, mergers, or restructuring. The field of change management inherits many tools and methodologies from psychology, sociology, business, and engineering.

Enterprise Resource Planning (ERP): A complex information system that allows for organization-wide coordination and integration of key business processes. Essentially, ERP systems provide a single comprehensive information repository to collect operational data from various business processes in manufacturing, finance, accounting, human resources, sales, and marketing. Through the use of ERP systems, managers can access more precise and timely information for coordinating the operations of their organizations. Currently, SAP and Oracle are the biggest ERP software vendors in the world.

Extensible Markup Language (XML): A simple yet powerful computer communication language developed in 1996 by the World Wide Web Consortium (W3C) as a more flexible markup language than Hypertext Markup Language (HTML) for creating Web pages. While HTML is limited to describing how data should be presented in the form of Web pages, XML can perform presentation, communication, and storage of data easily.

Information Technology (IT): A very broad term that refers to the products, services, methods, inventions, and standards that are collectively used for producing, storing, and disseminating information. Most of the time, the term is used in its more restrictive form to describe only the tangible infrastructure comprising hardware and software.

Outsourcing: In its most succinct form, outsourcing is defined as the process of hiring another person or organization to perform a service. In the Information Systems field, it refers to the practice of contracting computer center operations, telecommunications networks, or software applications development to external vendors. Goals of outsourcing are to decrease costs and free up management time by focusing on core competencies.

Productivity: A measure of a firm's efficiency in converting inputs into outputs. Essentially, it refers to the rate at which outputs are produced per unit of input (labor and capital). Productivity can be considered as either minimizing the use of inputs for a given output level (e.g., reflecting efficient production processes that minimize waste) or maximizing output for a given input level (e.g., reflecting the use of resources in the production of goods and services that add the most value).

Risk Management: Refers to a continuous process of identifying, assessing, and reducing a risk factor to an acceptable level, and implementing the right mechanisms to maintain that level of risk. Established risk management strategies include avoiding the risk, reducing the negative effect of the risk, accepting some or all of the consequences of the risk, or transferring the risk to another party through insurance.

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Knowledge Management with Partners in a Dynamic Information Environment

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INTRODUCTION

There are great challenges of the management in creative knowledge work, where individuals and information systems have a considerable role when the organisation is striving to achieve its strategic objectives. It is shown in this article that analysing the information and operational environments helps management in knowledge management and activates the organisation's awareness about the development needs of information systems.

The purpose of this article is to analyse the interaction between the dynamic information environment (IE) and the operational environment to promote the cooperation of the higher education institution with business life and enhance the external impact of the institution on its environment. The dynamic IEs are analysed to manage the information systems and internal processes in an educational institution and their cooperating partners.

This article is organised as follows: The article introduces the approach of IEs and operational environments. Then the concept of a dynamic IE is used to analyse the information systems used in the core internal processes of the higher education institution. The study also describes the partnership in a dynamic IE. Thereafter, a short case study is presented about partnership using the electronic Optima platform at the Turku University of Applied Sciences (TUAS). Finally, the results of the study are summarised in the concluding section.

BACKGROUND

Dynamic Information and Operational Environments

The approach of IEs is used in this article as a background to describe the different kinds of information systems in various operational environments. The approach of IEs was developed by Ståhle and has been applied in several studies (Ståhle & Grönroos, 2000, Ståhle & Hong, 2002; Ståhle, Ståhle, & Pöyhönen, 2003). An organisation is described in these studies as a knowledge creating system, where management and information systems influence the activities of individuals in various IEs. The classification includes mechanical, organic, and dynamic IEs.

Mechanical IEs increase the efficiency of internal processes and include thoroughly controlled information systems such as accounting and logistics systems, which are tied to the processes and structures of an organisation. The nature of information is mainly of the input-output type, where the functions of the information systems are to automate, steer, and report. Typically, time-consuming routine tasks are performed cost-efficiently using mechanical IEs.

Organic IEs emphasise dialogue, communication, and sharing of experience-based tacit knowledge (Kim, Chaudhury, & Rao, 2002; Nonaka & Takeuchi, 1995; Takeuchi & Nonaka, 2004). Organic IEs include, for example, feedback systems, management information systems, and library systems. The management information system is a tool which emphasises the communication and implementation of strategic plans. Two-way and open dialogue within the organisation is important. The system can be planned and constructed to facilitate strategic management and the balanced scorecard approach (Kettunen & Kantola, 2005; Kettunen, 2005, 2006).

Dynamic IEs aim to continuously produce innovations by self-organisation. An essential feature is that power and authority are not used but the process is led by the actor best suited for the task. The information in the dynamic IEs is obtained from the weak signals of networks. The dynamic IE typically reaches outside of the organisational limits and provides two-way access to the common information. The continuous and fast current of information reinforces the individuals for innovations.

The main idea of dynamic IEs and interaction with the operative environments is the strategic awareness of opportunities for virtual learning, interaction, communication, and diversity. In the learning process, open and grey areas can be found: virtual learning systems and networking, net casting and different portals connected with more risky, chaotic and innovative environments (Sauer, Bialek, Efimova, Schwartlander, Pless, & Neuhaus, 2005), and online networking platforms (Steinberg, 2006). The management and regional development process rely more on the open systems of the local, regional, and global partners of the TUAS.

Knowledge is accumulated through learning processes, which require both cultural and technological skills. Gathering explicit knowledge is relatively unproblematic because this type of data is codified and can be retrieved from mechanical and organic IEs. However, a great deal of knowledge is not codified and resides in the abilities and experiences of people. This knowledge can be gathered together in dynamic IEs. This knowledge may be of strategic importance but is difficult to acquire since it is not formalised and often concerns diffuse and context-sensitive matters. The way organisations enable access to uncodified knowledge is to invest in dynamic IEs, which support communication between individuals and interest groups.

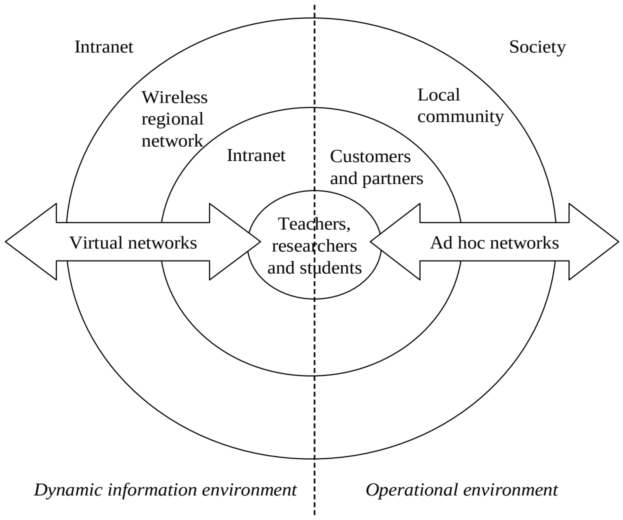
Figure 1 combines dynamic IEs and operational environments. The dynamic IE is the source where new innovations emerge by self-organisation. The information is constructed by the weak signals and tacit knowledge of virtual networks. Intellectual capital is one of the main factors of organisational development and innovations. The essential issues include the speed of information flow, the ways of information change, and the utilization and quality of information. The continuous movement and fast current of information reinforce the intellectual capital and the ability for innovations (Ståhle & Grönroos, 2000).

The operational environment of an organisation consists of the organisation and its stakeholders, customers and partners, local community, and society. Each organisation has to adapt its internal processes, resources, and capabilities to the changing environment in the strategic plan. Higher education institutions have to adapt their activities to the education policy, the local demand for labour, and the needs of stakeholders. The different operational environments can be seen as interconnected surroundings within each other. The surrounding operational environments may have diverse connections with the information systems of the institution.

Castells (2001) introduces a concept of ad hoc network, which typically appears in e-business and network enterprises. The concept of ad hoc network is also used to describe a group formed to deal with specific issues and disbanded after the issue has been resolved. These temporary groups provide solutions to problems that are not resolved by ordinary processes of the organisation. Castells defines the concept of a network enterprise, which is designed around a specific business project in the network. The business of the network enterprise is performed using ad hoc networks, which have the flexibility and adaptability required by continuous technological innovation and rapidly changing demand. A network enterprise open to suppliers and customers enables the enterprise to obtain information from specialists widely across the supplier organisation and customers to specify their needs. In this course of action, the exchange of information and the actors are tied together to an ad hoc social network, where the continuous flow of communication between individuals creates a structure where information and knowledge circulates.

The work groups and informal communities of practice have an essential role in the exchange of information and knowledge. Access to nonredundant sources of information is therefore important (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004). The structure of knowledge in organisational settings is often nested so that information circulates within work groups and informal communities rather than between them (Palonen, 2006).

Figure 1. Dynamic information and operational environments of the TUAS



THE CASE STUDY

Partnership in a Dynamic Information Environment

Table 1 describes the information systems in the dynamic IE supporting the core processes of the TUAS. The virtual learning environment Optima and local WLAN network called SparkNet are the information systems that most often appear in the different internal processes. Openness and cooperation have different kinds of needs and characteristics in the core processes. The Optima platform is a flexible information system for these purposes.

The higher education institutions in Turku, the City of Turku, the development company ICT Turku Ltd., and the supplier company MasterPlanet Ltd. established a regional infrastructure with a network solution SparkNet, which is the most extensive wireless network solution in Finland. SparkNet is used both in the private and public sectors providing wireless access to over 100,000 users. The network is also available free of charge in various public places, for example, in restaurants, cafés, cinemas, and offices.

The aim of SparkNet is to help organisations share investments and wireless data network resources. Instead of building their own wireless network, the members of the SparkNet cooperation build pieces of public wireless network with shared services in a wide area. SparkNet provides flexible tools for building a secure wireless network for local organisations and guests in a cost-efficient manner. The purpose of the institutions is to motivate local actors to become a part of digital information society locally, regionally, and globally. SparkNet provides easy access to mobile applications such as document sharing, video conferencing, Web TV, and voice over internet protocol (VoIP).

The TUAS and a software company Discendum Ltd. constructed an application of Discendum Optima virtual environment which comprises an Internet-based service created to support learning, project operations, teamwork, and other forms of communal activity. Optima can be used with an Internet browser in the wireless SparkNet environment as a dynamic IE. The purpose is to provide a virtual environment for creating, developing, presenting, and studying different contents in versatile interaction.

The members of the personnel and students carry out several kinds of activities in the Optima virtual environment including virtual courses, development projects, and assignments. The Optima platform is offered to partners of the TUAS to facilitate communication and interactive working. The R&D unit of the TUAS has extended the use of wireless infrastructure and platform into many project-related activities such

Table 1. Information systems in the dynamic IE supporting the core processes of the TUAS

Core processes	*Information systems in the dynamic IE*
Education	• Courses in virtual learning environment (Optima) • Open parts of library e-services • Co-operation platform of regional universities
R&D	• E-communities of practice in virtual learning environment (Optima) • Local WLAN net (SparkNet)
Regional development	• Optima e-networks • Optima community • Local WLAN net (SparkNet)
Management	• Intranet • IT Help Desk • Open systems of higher education partners • Local WLAN Net (SparkNet)

as the project management software Projektori, which is also a useful tool in publicly funded projects.

The Optima platform supports cooperation with the operational environment. The number of daily users in Optima is reported to vary between 2,000 and 15,000 persons, and the partners cooperating via Optima is estimated at about 5–50 organisations. Most of the interactions are connected to e-learning, but also many research and development projects are also online. Thus, the TUAS develops and provides learning and working environments which enable experiments and the study of new activities and procedures together with the companies and other working life organisations. The objective is to achieve customer satisfaction with e-networking and to create long-lasting customer relationships which enable lifelong learning and continuous cooperation between the educational institution and customer organisations.

Optima Partnership Between the TUAS and the TAD Centre

The case study of the partnership between the TUAS and the regional Turku Area Development (TAD) Centre is presented in this section. The objective of the centre is to create an environment that promotes entrepreneurial activities in the Turku Region by providing services for companies and entrepreneurs. The services include, among others, a business directory of over 13,000 local companies, the location memo to companies considering relocating their operations, and the database of vacant real estate in the region. The search engine of the TAD Centre helps customers find the companies and real estate by name, product, or service.

The TAD Centre was established to foster continuous economic growth and employment in the region. The centre carries out strategic development projects, coordinates regional business policies, and creates prerequisites for wide-ranging enterprise activities. It combines human resources and funding by the municipalities committed to developing trade and industry. The economic transformation of the region is supported in cooperation with companies, research units, educational institutions, and the local authorities. The need to develop electronic services is obvious for the TAD Centre to achieve its objectives. The TAD Centre is currently considering different types of collaboration partnerships with various actors, including the TUAS.

Collaboration between the TUAS and the TAD Centre is natural because they are both owned and maintained by the City of Turku. The strategic objectives the TUAS and the TAD Centre are aligned to run parallel. The cooperation includes, among others, regional development and the creation of partnerships in order to strengthen regional networks and clusters in both the public and private sectors. From this background, the jointly developed information system could also generate synergies to the other operational areas.

The TUAS is one of the regular partners of the TAD Centre. From the point of view of the TUAS, the purpose is to develop partnerships, the extranet of the institution, and customer relationship management (CRM). Although the Optima platform is not a specialized CRM system, some of the operational advantages of CRM can be achieved using it. The TUAS suggested the TAD Centre should use the Optima platform for different purposes. The basic user activities of Optima are easy because Optima has a folder structure and is already linked to some other information systems of the TUAS using the lightweight directory access protocol (LDAP) of the institution.

The information systems of the TAD Centre include the Web site (http://intratad.turku.fi), databases in Lotus Notes, and networking on the Intranet of the City of Turku. The future role of Lotus Notes was unclear. The consulting of the TUAS detected a need for an outsourced application service provision (ASP) concept, which provides cost-effective and worry-free solutions and services. The TAD Centre appreciates innovative and versatile learning and networking solutions but wants to avoid the time-consuming work of acquiring and maintaining its own virtual environment. Thus, the specification of the software should include at least rapid implementation, ease of use, reliable and fast operation, high data security, and cost-effectiveness.

The first cooperation agreement included the opening of a subenvironment in the TUAS Optima virtual environment and personnel support and education by the e-learning unit of the TUAS. The experiences were analysed and reported to the partners of the development project after the pilot period ending in autumn 2006. The project plan for the subsequent effort includes four to six pilot work area applications in the subenvironment of the TUAS. Then, the TAD Centre will consider a possible agreement with Discendum Ltd. to establish a permanent Optima virtual environment.

FUTURE TRENDS

The vague needs of the operational environments are the driving forces of development and future trends. The weak and strong signals are typically derived from outside of the organisation. Networked information and communication tools and skills are needed in the post-industrial information society and organisations. There is an urgent need to develop the skills of organisations to catch the uncodified information and tacit knowledge obtained from the partners. The ICT cluster is one of the most prominent clusters where economic growth and employment are expected to emerge. The strategy of the TUAS focuses on the development of the ICT cluster in Southwest Finland.

The logic of management and information flows follows the processes and structures of the organisation in the mechanical and organic IEs, but in dynamic IEs the signals for the innovations can be obtained from ad hoc networks and virtual networks including modern wireless equipment. Organisations can achieve competitive advantage if they operate successfully in dynamic networked environments. Interaction, networking, and opening activities to existing and potential partners are the main elements of the success and innovations.

CONCLUSION

The article provides a useful tool for the development of information systems in networked environments. The IE approach was introduced and described. The approach was further developed to describe the dynamic operational environments of a higher education institution and its partners. A case study was presented of how to apply the theoretical concepts of IEs to practice at the TUAS. Outreach and engagement in business life are of increasing importance in educational institutions.

The IE approach helps management find how the information systems are connected to the core processes of the institution. The approach also helps management get the big picture of how the information systems settle in different IEs. The analysis enables the consideration of the balance and functioning of IEs in different operating environments. On the other hand, the analysis helps management detect the possible deficiencies of the information systems and make investments in new systems to support the effective functioning of the core processes.

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KEY TERMS

Dynamic Information Environment: The virtual surface of the organisation, which is used for seizing the world outside. The main idea of the dynamic information environments is the strategic awareness of the potential of virtual learning, interaction and communication.

Higher Education Institution: Higher education institutions include traditional universities and professional-oriented institutions, which are called universities of applied sciences or polytechnics.

Information Environment: Mechanical, organic or dynamic area of information management consisting of different interrelated and/or isolated information systems.

Information System: A system, whether automated or manual, that comprises people, machines, and/or methods organised to collect, process, transmit and disseminate data that represent user information.

Knowledge Management: A term applied to techniques used for the systematic collection, transfer, security and management of information within organisations along with systems designed to help make the best use of that knowledge.

Management Information System: A proper management information system presupposes modelling the entire management process and tailoring all the necessary components of the information technology support system to meet the needs of the organisation. The management information system should include a description and measures as to how the strategic objectives will be achieved.

Operational Environment: The operational environment of an organisation consists of the organisation and its stakeholders, social networks, the local community and society. The organisation has to adapt its internal processes, resources and capabilities to the changing operational environment in the strategic plan.

From Knowledge to Personal Knowledge Management

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INTRODUCTION

Personal knowledge management (PKM) is a conceptual framework applicable to personal knowledge. It is about taking an individual responsibility towards one's competencies in the community where one belongs, be it an enterprise, a professional group, an institution, a class, and so forth. PKM implies developing methods and skills in using software and hardware technologies specifically applied to knowledge. These ideas are capturing much attention and analysis, but there are no books about PKM. PKM is an emerging discipline that sometimes challenges the principles of KM (Knowledge Management), from which it descends.

To understand PKM we need to consider first the concepts of *knowledge* and *knowledge management*. Some widely shared beliefs are the following:

- Knowledge is so valued today that our society defines itself as a " knowledge society";
- Knowledge management is not a technology or a software solution, it is a discipline;
- We are able to make distinctions among different forms of knowledge, that is, *explicit*, *tacit* and *implicit* knowledge, and see their transformations.

Even though we may share a global understanding, knowledge appears to be an unstable concept, continuously generating new waves of reflections as well as controversy (for an outstanding example of dissent see: "The Nonsense of Knowledge Management" by University of Sheffield Professor Emeritus T. D. Wilson (2002). One cause of change is the powerful effect that the *new* technologies (advanced ICTs, digital technologies, the Web, etc.) have induced in every domain where we apply cognition. Under the effect of technology, knowledge acquires a dynamic property and we can interpret it as a communicating system, a *knowledge ecosystem* (Community Intelligence Labs, 2000; WC3, 2006).

Knowledge Management vs. Personal Knowledge Management

To define KM let us look at the following two citations: the first, originally formulated in 1988, is by the renowned Karl Wiig, one of the founders of KM; the second is taken from a 1999 U.S. Army report:

The purpose of KM is the systematic, explicit, and deliberate building, renewal, and application of IC [Intellectual Capital] assets to maximize the enterprise's knowledge-related effectiveness and the returns from these assets. (Wiig, 2004, p. 48)

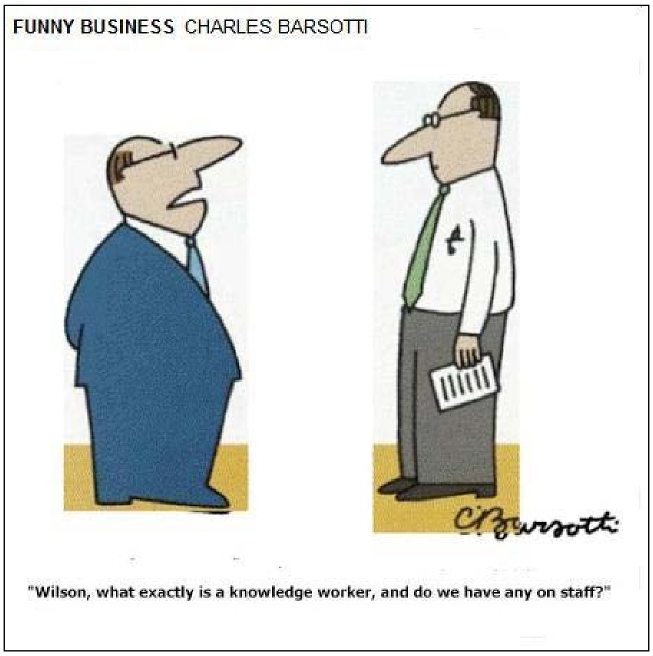
Knowledge Management is an integrated, systematic approach to identifying, managing, and sharing all of an enterprise's information assets, including databases, documents, policies, and procedures, as well as previously unarticulated expertise and experience held by individual workers. (EI.pub, 2002)

These two statements well characterize what was, at the end of the past century, the prevailing interpretation of KM. At that time, the so-called "knowledge worker" existed only *inside* the enterprise (as in the ironic cartoon by Barsotti, Figure 1). KM was a corporate affair related to being competitive in business and was implemented as a set of practices with a top-down approach that exclusively favored corporate priorities. *Personal* Knowledge Management, instead, takes a different route.

The Motivation for PKM

PKM is a concept with depth and complexity, but its rationale is clear and simple: if knowledge is power, a precious asset for attaining leadership and self-realization, why should it not be at the center of an individual's *personal* aspirations and efforts? Why should it not be the object of a specific skill development effort?

Figure 1. Cartoon by Charles Barsotti, image courtesy of the author (http://www.barsotti.com)



Managing Knowledge means Managing Oneself, is Peter Drucker's title of an illuminating essay (Drucker, 2000). Therefore, the concept of knowledge as a fundamental *personal* asset of the knowledge worker, and not just a corporate asset, was already very clear to the best minds at the start of the century. However, when Drucker was speaking in 2000, not all the elements needed to trigger a change and start PKM as a new strand of KM were yet available.

"*Knowledge gives choice*," said Drucker in that essay. However the question was: how, in practice? There was no way then for the individual to make available for personal use anything like the very expensive knowledge management computer-based systems that only enterprises could afford. Away from the office, or from school, or higher education, the individual only had for himself the rather blunt, PC-based "productivity tools" that we all know. However, only a few years later, there would be a profusion of new, powerful, and affordable software and hardware technologies, Web-based and supporting multimedia. They would give rise to a generation of "PKM tools" specifically designed for the *individual* user. What made the difference were those enabling technologies, accompanied by a greater awareness of the role of the individual worker.

THE FOUNDATION AND THE EVOLUTION OF PKM

It is the educational, and not the enterprise sector, that has given birth to PKM and its techniques. Its origin is in the university environment, in the years after 1999, in two U.S. institutions: first at UCLA, Los Angeles, CA, and then at Millikin University in Decatur, IL. Initially PKM has been an isolated concern of universities but subsequently it has been re-interpreted as valuable in all environments, including private enterprise.

UCLA Anderson School of Management's Approach to PKM

In 1999, at UCLA, Professor Jason Frand of the Anderson School of Management and his colleagues set for themselves a very pragmatic objective: to create a program for their MBA students that would help them face the information explosion, a problem particularly felt at that time caused by the growth of the Web and the effects of personal publishing. Here is their judgment, as stated in their key paper:

Our students, who will spend most of their working lives in the 21st century, will need to see the computer and related technologies as an extension of themselves, as a tool as important as the pencil or quill pen was for the *last several hundred years. […] Personal Knowledge Management (PKM) attempts to utilize the computer to help the individual manage the information explosion in a meaningful way (Frand & Hixon, 1999, p. 1).*

The objective of the PKM program was to teach students some basic KM principles and their application, using computer-based tools, so that students would acquire a mindset and a methodology enabling them to process information and transform it into knowledge. In turn, the academic staff had to learn and adjust to the profile of the new "Information Age" generation of students (see "The Information Age Mindset" Frand, 2000). Their view of knowledge in the academic context is clear-cut:

"Knowledge is a product, it's something you can go to school and acquire"… Also: Begin with data. Add context to get information. Add understanding to get knowledge. Add judgment (values) to get wisdom." (Frand & Hixon, 1999, pp. 4-5)

At UCLA, the training for PKM concentrated around five tasks:

1. Searching/finding
2. Categorizing/classifying
3. Naming things/making distinctions
4. Evaluating/assessing
5. Integrating/relating

The Anderson School's conceptual framework, with its very realistic setup, has been, and still is, a fundamental reference for all PKM developments. Not many specific tools were available at the time, but Frand and Hixon had the correct intuition that a large technological development would soon follow, as it did.

The Millikin University's Approach

The developments at Millikin University are due to Professor Paul A. Dorsey, Associate Professor of Management Information Science, and his team. According to Dorsey and colleagues:

Personal knowledge management is best viewed as based on a set of problem solving skills that have both a logical or conceptual as well as physical or hands-on component. (Avery, Brooks, Brown, Dorsey, & O'Conner, 2000)

PKM, as defined at Millikin, consists of seven "information" skills:

1. Retrieving information
2. Evaluating information
3. Organizing information
4. Collaborating around information
5. Analyzing information
6. Presenting information
7. Securing information

These skills are thought capable of obtaining for the individual a strategic balancing of performances, in the public or private sphere of life and in intrapersonal or interpersonal relations.

When we look at how these skills were defined (Dorsey, 2001; Millikin, 2003), we find that the effect of time is very noticeable, even though the research was done just a few years ago. Today's view on the same set of skills would have to introduce several changes and amplifications. For instance, with reference to (1), sharper skills are required today to exploit the new generation of the so-called "super-search engines" (e.g., multimedia-, citation-, "scholarly" engines). With these tools, mastering the calibration, the adjustment of settings and the interpretation of results is a new type of effort. Managing the new media is also a challenge. Much information is coming via streaming media, so "listening" now takes an increment of difficulty (listening to a Webcast is more demanding than listening to face-to-face speech). With reference to (2), there is an important change from the past: much information today is no longer qualified and ranked by "authorities" but rather by "crowds", that is, by the user themselves. Many items of information are found today "already ranked" (with kudos, tags, etc.). From blog posts, to Web pages, to pictures, most material produced by the frenzy of folksonomies carries a grade. The tagging revolution, or "folksonomy", requires, when assessing a piece of information, a complete new understanding and approach by the user, which is involved in parallel processes of fruition and creation. With reference to (5), we are now beginning to see some innovative software tools, unheard just a few years ago, for the task of analyzing information and extracting meaning from data: "summarizers", keyword extractors, and

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"relevance" engines. However, learning to use these tools is becoming a specialist's activity and, in all cases, the human element remains the fundamental decision engine.

DEVELOPING PKM SKILLS

The pioneers of PKM proved that developing skills to create and maintain "personal" knowledge is not a casual activity. Skills can be taught in an academic environment, they can be instigated and facilitated in an enterprise environment but, in all cases, an act of self-responsibility on the part of the individual is fundamental and necessary.

PKM requires a conscientious and continuous investment of time and resources. It is a matter of craftsmanship: the knowledge worker should take continuously care of his tools and pay attention about what is new in his trade, as it would be for any other kind of worker, such as an artisan or a mechanic.

The seven skills of the Millikin project are a good reference model, which, however, can be updated and further developed. The Millikin approach, as KM scholar Steve Barth remarks, has a shortcoming: it only deals with information. Barth suggests adding in each entry of that list the word "ideas" to information, for example, "Presenting information *and ideas*" (Barth, 2003). The effect is that the skilling process will address not only information but also products of the mind, that is, *knowledge.*

To update the model in question for current times, it is necessary to envisage additional skill requirements, taking into account a social dimension that was indeed noted at that time (row 4 in the Millikin list earlier), but that presently is much more visible. Here are some socially oriented PKM skills that are destined to be more and more required over time:

- Ability to meaningfully master an IM exchange: for example, conciseness, understanding the concept of turn, focus, no rambling, and so forth;
- Managing contacts: keeping an accurate profile of one's correspondents, including what information tools they use, what digital equipment they adopt, on which channel they can be reached, and so forth;
- Ability to adequately perform when immersed in virtual environments and acting and reacting in real time (as in an online classroom, seminar, business meeting, project, etc.); ability to exploit the new features of technology-supported human exchanges (information visualization, post-processing of recordings, digital annotations, automatic abstracting, etc.)
- Ability to communicate in several languages (very valuable knowledge exchanges can be achieved when speaking the native language of our correspondents).

Yet more skills can be envisaged, which we could call "future skills", because their need will be greater in the future generations, when wireless and ubiquitous communications will be fully pervasive and computing fully "ubiquitous". A case in point is the advent of location-awareness and presence management tools. In a world that is always "on the move", mobile data services influence the ways we use context and media to refine our knowledge processes: "*Presence management will change the way we use all person-to-person communication media and will affect almost every network service*" (Smith Grubb, 2004).

PKM TOOLS

PKM does not exist without tools: technological support is necessary to enact this discipline. PKM tools are abundant and varied, but appear still immature when we try to identify "toolkits". This is typical of a young market, but there is a very noticeable trend to offer more refined, more comprehensive and also "opensource" products.

The list we present (Table 1) shows elements of what is almost a new technique, a new way to use the computer. Some of the categories will appear familiar but the difference lays in the tools design, which is meant to appeal to the IKW (Individual Knowledge Worker), rather than to the Manager of the ICT Purchasing Department of a business enterprise.

New PKM tools are continuously proposed under the push of the Web 2.0 technologies. A "for beginners" list can be found at the University of Victoria Faculty of Law (UVIC, 2006) while the use of PKM tools inside an enterprise is well discussed by in an IT Pro Magazine issue (Clemente & Pollara, 2005).

Table 1. PKM tools

Category	*Function*
News aggregators, feeds, blogging engines, metadata creation tools	It is the repertoire of tools of any blogger or personal publisher.
Multimedia management tools, authoring tools	Video and voice recording and editing, speech-to-text and text-to-speech translation, speech annotation, and so forth.
Advanced browsers	Not only browsing, but also added values like: tracking the user's navigation, providing chronologies, caching effects, filters, keywords discovery, security features, and so forth.
Mind mappers, concept mappers	Many new products are appearing, merging several functions (e.g., searching, information capture, annotation, etc.). The distinctive feature of these tools is "information visualization", an advantage for understanding complexity.
IM facilities, voice and video conferencing	The "Skype" paradigm is the reference, often augmented by features aiming at better usability.
Web assistants	Very flexible, "swiss-knife" kind of tools, providing support for any kind of manipulation of Web-resident information.
Knowledge discovery	Emerging, still quite rare, tools of advanced design acting on large-scale information depots, either personal or corporate. The objective is attempting to find patterns, relevant concepts, relations, keywords, taxonomies, and so forth.
Personal schedulers, also called GTD (get things done) tools.	Provision of time and task management, notebooks, scrapbooks, contact lists. More sophisticated features are meetings planning and scheduling, presence and location management.
Collaboration software, shared workspaces	Tools allowing multi-user collaborative activities of many kinds: distributed project management, distributed workflow, wiki-like cooperative document creation, whiteboards, gaming, near-immersive spaces, and so forth. This is the area of foremost research and development, but also the most challenging in design: tools must be capable to manage simultaneously local, individual resources and team resources in distributed locations.

CONCLUSION

What are the advantages of implementing PKM?

- If one is inside an enterprise, the competitive advantages will be most important: to become a high-quality source of information will increase one's value; agility in evaluating disparate amounts of factual data, messages, and events will be considered precious business insight and will attract cooperation and recognition;
- If one is an independent professional, visibility and competency will be the drivers: "*effectively managed personal knowledge assets become the currency of personal intellectual capital*" (Barth, 2000);
- If one is a researcher, the speed and quality of one's investigation activities will be improved, providing more time and opportunity for study and reflection;
- If one is acting in the private sphere, one can use the same kind of tools to keep one's net of rela-

tions current and cultivate personal culture and interests.

The word "personal" in PKM should not be read as "selfish": knowledge needs the institution of the community and the dimension of networking to exist and grow. However, it necessary for anyone, from young student to adult professional, to learn to manage one's personal knowledge first, before claiming that it can be shared with others.

The view of knowledge's role in society and economy and the methodologies about managing knowledge that were current in the past century, do not appear adequate to interpret today's times. KM expert Denham Grey (2005) points out that PKM should concentrate on "social" skills and networking of minds, rather than on technology aimed at managing "individual property".

There is an important difference with the past caused by the availability of extremely powerful and flexible communication means and the disseminating power of the "new" Web, the so-called Web 2.0. People now live, learn, and work in a space dense with messages and connections (Siemens, 2006). Knowledge can no longer be tied to artifacts or repositories, but it becomes a "flow". Creating a Personal Knowledge Environment around oneself, therefore, shall mean to master *knowledge as a flow*, that is, the dynamics of rich but continuously changing content and the multiplicity of engaging but transient relations with one's peers.

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KEY TERMS

Folksonomy: Folksonomy is a neologism, a word constructed by mimicing another word: “taxonomy”. A taxonomy is a hierarchical data structure whose purpose is to classify elements of a given domain: nature, science, knowledge, and so forth. Folksonomy indicates a trend of recent times, becoming almost a philosophy, that contrasts formal classification methods, because the definition and organization of the elements is based on the judgment and the concourse of generic “people” (folk), usually gathered in communities, and not of “authorities”.

IM (Instant Messaging): Instant messaging is real-time communication between remote correspondents over a network, typically the Internet. IM (text) services and tools are extremely popular and available on all kinds of computing devices. Modern IM software solutions offer many more features than just message transfer, such as presence management, correspondent management, conversation logs, file transfer and support of video and (asynchronous) voice mail. Synchronous voice messaging is known as “chat” and is also very popular.

Metadata: Metadata are data about data. A simple example is the label on a box, which tells “about” the content. Metadata used to belong just to the cultural domain of librarians but, since the Web, search engines and the “open knowledge” movement, it has become a concept much more widely known. Metadata are vital to retrieve data from repositories, namely the Web and are necessary to associate meaning (i.e., knowledge) to information. There are, unfortunately, many standards pretending to regulate metadata creation for digital content. One of a few to have some status is IEEE LOM (learning object metadata) (http://ltsc.ieee.org/wg12/).

Mobile Services: An expression to indicate generically all communication service that use radio waves, but currently more directly referring to wireless voice and video telephony, and wireless computer communications. Advanced mobile *data* services provide information and service based on the user geographical location obtained though the GPS (global positioning system).

News Aggregators, Feeds: The most used term for these items is actually RSS (or RSS *feed*), an acronym whose interpretation is uncertain, the most popular one being “really simple syndication”. A news aggregator is a software application that collects syndicated content from disparate sources and provides a single consolidated view. As a tool it is used in blogs and works like a reader, therefore it can also be referred to as a “feed reader”.

Presence Management (PM): With people always on the move and hooked to anyone of the many communication devices available in our times, “reaching” one’s correspondent has become a vital necessity. PM tools give users control over how they appear on a communication link, for example on the online connection over the Internet. The most advanced tools are integrated with IM, attempt to cover all channels (e.g., including voice) and provide “status messages” that at each instant inform the external environment about the state of presence of the user.

Relevance Engines: Relevance engines are advanced search engines emerging from recent developments in the field, aimed at improving the meaningfulness of search results. Looking for a piece of information is not a standard process. Selecting and interpreting the result of a search are activities whose outcome is deeply dependent on the mindset of the searcher and on the context of the operation. However, even the “best” search engines, for any given search, always give the very same result to different persons and in different situations. Instead, relevance engines, using special algorithms and different philosophies, attempt to take into account the specific parameters of a search, that is, its *context*. One engine, for instance, collects anthropological and professional data about the searcher and, based on them, proposes to focus the search on alternative knowledge domains. Another very clever engine, installed in the PC, continuously "watches" the activity of the user and, based on what he does, what tools he calls out, what material he manipulates, "speaks" in a side window. It provides, in real time, suggestions,, pointers to information, document excerpts and categories appropriate to the domain of "knowledge" that emerges in the working environment of the user. *Relevant* information is found *without* any need for a search.

Learning Processes and ITC

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ICT AND THE LEARNING SOCIETY

Confronting with the educational emergences defined—in the white paper presented in 1995 by the European commission with the title "Teaching and Learning. Towards a Society of Knowledge"—the Commission identifies three main factors of upheaval: information society, internationalization and the world market, scientific and technological knowledge. These factors involve a modification of the systems of knowledge and work, and, as a consequence, also of educational politics which must promote a personal development of citizens through the development of the necessary competences in dealing with these factors.

The consequences that emerge are the reported in the next section. First of all, the society of knowledge is linked with a condition of uncertainty and risk of social exclusion, which determines a great disorientation for the individual. The individua is exposed to infinite cognitive potentialities on one side, but also to a cognitive weakening on the other side. Among these risks, the first is a disorganized and confused fruition of the knowledge resources offered by the symbolic world in which the individual is plunged in. He/she is irreparably depressed when plunged in an infinite net of knowledge which the individual can not reach in a critical way, being also bombarded by pervasive—usually persuasive—information of mass-media pushing him/her toward homologation.

Another risk is linked with the traditional school curriculum: the individual stores up a static series of set portions of knowledge, transmitted usually by outdated strategies, but the individual is not stimulated to "learn to learn", which is what is needed to be able to face and actively take part in the post-modern society.

The indications provided by the white paper are clear: in order to be able to confront with a quantitative increase of information and forms of knowledge, as well as an increase of complex, fluid (Bauman, 2000) and changing situations, what is needed is a formative planning which aims at fostering knowledge and general culture on one side, that is, spread in a capillary way the ability to catch the meaning of things, understand, be able to act, choose, create, adapt to the present complex social condition; on the other side at developing an aptitude at occupation, that is to say encouraging —through an access to lifelong learning, e-learning and promoting ICT—the social mobility of citizens (workers, students, adults, young people).

At a careful analysis it is clear that the current "society of knowledge" is tied to a culture that regards education only as a function of market needs, thus penalizing a knowledge considered unnecessary and favouring a reproductive idea of competence against a critical, constructive and transformative competence.

It is therefore arguable that the most important part of what we define "understanding" is actually linked with the activation and structuring of feeling. The dimension of feeling helps everybody to "become him/herself", to grow up, or, vice versa, leads to a missed existence when this only chance fails (De Monticelli, 2003).

The European Commission, finally, suggests five general objectives in order to create a "learning society": *encourage the acquisition of new knowledge*, that is, raise the general level of knowledge, implementing new systems that recognize technical and professional competences beyond what is stated in diplomas; *bring school and the business sector closer together*, that is, develop a professional training system that keeps up with new conditions in production and with the needs of the world of work, also with the promotion of apprenticeship/trainee schemes at European level; *combat exclusion*, that is, offer a second opportunity to all the categories of population left by the wayside (young people with no qualification, older workers, long-term unemployed, women) to improve their social status. This can be achieved through an adequate training offer, complementary funding, consultation and partnership with firms—for example a firm could support a school offering working opportunities to the people who successfully complete the vocational course; *develop proficiency in three European languages*, *treat capital investment and investment an training on an equal basis*, that is, encouraging by positive measures firms and public authorities which pay education particular attention.

However it would be the case to face the problematization with a thorough consideration on training politics, as the knowledge of the contemporary age requires the rethinking of the entire scholastic knowledge.

This is in line with a complex cognitive system directed towards the flexibility of knowledge, the fading of disciplinary boundaries and the extending of interconnections among cognitive worlds (although formative institutions are still anchored to abstract forms of knowledge and to reproductive teaching/learning strategies, which are not easily capable of managing the complex evolution of the cognitive knowledge). Difficulties of the educational system in confronting with the new requirements in competences arising from the "society of learning" highlight how urgent it is to rethink a possible new conjugation between "symbolic-reconstructive" teaching/learning forms and experiential teaching/learning forms using ICT.

The education of the mind is not a problem of pure application, but it is both a research and education program and a program concerning the living model of organization of the production processes and personalization of knowledge and experiences, which we generally call learning.

Living in the "global village", that is to say in an enormous and pervasive hypertext, even in their contribution to the development of this metaspace the new generations conform their learning styles, their lives, and briefly, their minds to this specific environment.

As Pierre Lévy argues (1996), the cyberspace is the support of intellectual technologies which amplify, exteriorize and modify several human cognitive functions such as memory (e.g., hyperdocuments), imagination (for ex. simulations), perception (for ex. virtual realities), reasoning (e.g., modeling of complex phenomena). Moreover such intellectual technologies promote new forms of access to information (e.g., surfing the Net, knowbots), new reasoning and cognitive styles such as simulation: a real industrialization of thinking practices which does not depend either on logical deduction or induction from experience.

ICT AND LEARNING PROCESSES

The attention given by the constructivist approach—by the culturalism approach (Bruner) as well as neo-piagetian and neo-vygotskian studies—to the intrinsic constructivity of thought and its rooting in the interactions of the individual with the world in which the individual realizes the experiences, become real in the enhancement of the individual dimension in the learning/teaching processes on one side; and it is based on the enhancement of its social dimension on the other side. Starting from these preliminary remarks it is possible to sketch an effective educational and training frame for the learning society, since the association of the individual dimension of every single student's building processes of his/her cognitive identity to the inter-subjective and cultural dimension allows the establishment and maintenance of a link between the self-constructed *autonomy*—defining the meaning on the free explanation of the training path of every individual—and the coconstructed *dependence*—defining, on the other side, the indissoluble/relentless rooting in a net of relations inside a community: in a system of shared responsibilities and mutual commitments (Rivoltella, 2003; Wenger, 1988; Varisco, 2002).

The culturalist approach, as well as a "culture of education"—linked with the achievement of mass education, didactic planning, and life-long learning offers—based on knowledge and competences confirmed the emancipating function of education (knowledge and competence are considered as the basic propelling element for individual and social progress) without omitting the contradictions and unsolved problems (referring to the Italian context) such as the high percentages of school drop-out, demotivation, waste of intelligences, new-illiteracy (Frabboni, 2004, 2005; Frabboni, Pinto, & Minerva, 2001; Trentin, 2001).

In this frame, with a raising cultural and social complexity—where the changing request, the recursion and the connection refer to the plurality and the problematic nature of reality, experience and thought itself—education is going towards specific knowledge and competences. It is about knowledge and competences able to support multidimensional, open and problematic view of the individual on reality and knowledge itself (complex, uncertain, and plural). This can be achieved through an educational planning that trains the thought to organize connections even between things that seem far and disconnected, that knows how to handle with courage the uncertainty of reality with a radical multidimensionality and opening to difference. It is what Edgard Morin (2000, 2002) defines as "complex thought": a thought that is able to understand the multiplicity of different threads—multiple knowledge—building the complex net of reality.

This way, the evolution of electronic technologies of a simulative kind opened up the field to innovative solutions in optimizing the educational processes through direct experiences with experiential forms of teaching-learning, which show how immersion in realistically reproduced environments ("simulated" on the basis of dynamic models)—made possible by "virtual" technologies—offers to the individual specific and real contexts of experience, and puts him/her in the position of manipulating the variables involved. In this way the individual is invited to build nets of knowledge corresponding to the cognitive needs which emerge during the task. At the same time this stimulates learners to put into practice associative, analogical, horizontal and interactive procedures, and it allows them to move inside more or less systematically organized cognitive contexts, yet not rigid. What follows is that the learners themselves reach an effective and multi-dimensional learning (Anderson, 1998; Calvani, 2000; Galliani, 2004; Haughey & Olson, 1979).

In the context of the recent expansion of electronic technologies, new practices based on connectivity, ipertextuality, interactivity, operativity are getting more and more important and suggest alternative models of thought and knowledge. Multimediality and interactivity of new media, generating networks among permanently moving "knots" of knowledge, break the traditional structure of knowledge and define it as a "dynamic space" that can be read thanks to two new metaphors: "knowledge-flow" and "knowledge-network". The metaphor of "knowledge-flow" fights against the idea that fixed portions of knowledge inside static boundaries defending the peculiarity and self-referentiality, and suggests an alternative idea of "totalities of meaning partial and provisional, that is, areas with an always changing meaning, open to "active filtration" of information and knowledge coming from the outside (Lévy, 1996, 2000). The metaphor of knowledge-network recalls the idea of getting over the linear and hierarchic organization of knowledge, which takes into account what neurobiological studies are revealing about the functioning of the brain, which endlessly works by building and modifying networks of "relations" (between neurons, concepts, knowledge), where the "knots" of the network become themselves networks (Pinto Minerva & Gallelli, 2004).

From an educational point of view this has roused a multidisciplinary consideration on the relationship between knowledge and competence. Starting from the psico-pedagogical studies of the 1980s, researches agree in stressing that the "experts" and competent individual, directly observed in their own specific working contexts and interactions with colleagues, present the following characteristics: *organization, articulation, contextualization, flexibility.* Moreover, the constituent components of *expertise* are the *poli-contextuality* (the ability of diversifying one's own performances, adapting them to different contexts) and the *crossing of borders* (the ability of negotiating solutions with colleagues in different ways, using charts and sketches, to facilitate the confrontation of different competences). The competence is, therefore, a complex ensemble of abilities: an ensemble of abilities that depend only partially on personal strategies and more on the interpersonal system of activities in which the individual is involved. It emerges from a reticular system of declarative knowledge, procedural knowledge and conditional knowledge that is realized between the action and individual cognitive processes, and the relations that the individual establishes and has with other individuals involved in concrete practices of research and solution of problems (through the mediation of a series of technical and symbolic tools). The process through which the individual moves from a simple application of knowledge and rules using reproductive patterns, towards a more mature *expertise,* involves the access to forms of "complex learning". It is about the acquisition of *integrated competences,* resulting from the combination of comprehension and organization of concepts (cognitive component), aptitude in transforming knowledge in a personal value (motivational component), aptitude in improving competences and performances drawing on the resources of the context (contextual component). The acquisition of competences in a specific field of knowledge, therefore, coincides with the capacity of building strategies in applying non-repetitive knowledge and abilities, in dealing with knowledge in an active and participate way, in developing creative aptitudes of autonomous and self-regulated building of knowledge and also metacognition (Ajello, 2002; Cambi, 2004; Flavell, 1979; Goleman, 2006).

The pedagogical problematization on the role of the school in the education of competent individuals requires a change in perspective. The debate of the past few years on the concept of competence is leading the present transition towards an educational system concerned about the development of competences that are, at the same time, sectional, flexible and convertible. Besides, it helped to focus the attention on the active dimension of knowledge: a dimension that involves a revising, transferring, applying ability which has lead to a crisis in the traditional pedagogical system (based on the linearity of knowledge and on pedagogical approaches focussed on symbolic-reconstructive procedures, rather than on research and coconstructing knowledge, e.g., in workshops/atelier). This lead to the reappraisal of the theory of experience suggested by Dewey, who, in the 1950's, went beyond the dualism thought/action, theory/experience, authority/democracy and set the basis for the existing models of situated knowledge (Dewey, 1966; Maragliano, 1998; Solomon, 1993).

The virtual approach, in this perspective, offers the possibility of starting again from the centrality of the learner and his/her learning. An active learner in the net, co-producer of education and of virtual realities, protagonist of his/her formation as "co-constructor of common meanings". The virtual—where it is combined with learning—operates an epistemological revolution: a revolution involving both the participants to the educational processes and the researchers who study the practices in use. Even if the increase in connections of humanity with itself and the hypothetic, virtual shortening of distances between North and South of the world—which will be dealt in the following paragraphs on digital divide—does not automatically entail a greater equality among humans, we can however claim that ICT and digital communication create and develop an *expansion of the individual conscience,* unknown in the past. The phenomenon of virtual learning communities and of "connective intelligence" that is taking place strengthens in a natural way the centrality, and therefore the power, of big consolidated centers—intellectual, economical and political—in the North of the world. Yet at the same time it is used—and one thing does not exclude another—by social movements, solidarity nets, development initiatives, pedagogical projects, changeable forms of cooperation, exchange of knowledge and of experiences in a more participating democracy. The kind of power promoted by the extension of the cyberspace is clearly not the hierarchical, bureaucratic, or territorial one of the past: it is a power that arises from the ability to learn and work in a synergic and democratic way, a power that is proportionate to the degree of reciprocal trust and recognition which masters the human space. A *habitus* based on the density, speed and qualitative diversification of links and exchanges. The question of power (or centre) and exclusion (or periphery) sends us back to what we are collectively able to support (or to choose) as responsible, *engagé* citizens.

What is, now, the relationship between the reconnection of the human species with itself (process of globalization) and the expansion of knowledge and citizenship? It (globalization) certainly produces a spread in human horizons and if the movement of interconnection were not linked to an advance in knowledge it would not represent a real progress. For this reason it is possible to suppose that the global interconnection is only the material side of the conscience expansion, as the two movements always go together.

ICT: POSSIBILITIES AND EDUCATIONAL PERSPECTIVES

The technological and scientific revolution has been growing faster and faster in the past decades, filling our daily life with information and messages, symbols and meanings, multi-faceted and sophisticated instruments. This acts on the entire space of experience and not only on communication, but especially on culture itself. It boosts the complexity of the world of communication, where you can find—side by side, overlapping, coexisting—old and new media, creating new stimuli and new possibilities of experience in a varied situations of daily life, such as work, leisure, study, and private life, thus changing in an unthinkable way rhythms and modalities of existence (way of life). However, this proliferation of communication tools (satellite television, internet, mobile phones) cuts physical distances and speeds up the possibility of sharing information and cultural products coming from distant places on one side, but on the other side this quick movement from one place to another modifies the perception of spatial-time barriers, and forces upon the individual the need of being "connected", being in touch, if he/she does not want to feel excluded/out.

Yet this cultural complexity has a paradox. On one side the technological evolution offers occasions to build new knowledge and multiply training experiences, on the other side the high and diversified offer of information introduces in a fragmented, contradictory or, even worse, in a homologated or homologating archipelago (responding to market standards or models). We are, therefore, in front of a paradox: the virtual widening of possibilities in cultural enrichment goes together with a more and more limited freedom of choice, because there is a prevalence of a pervasive tension toward a linguistic, cognitive, existential leveling, and standardization.

This is the reason why we need to promote in new generations—at school but also outside school - knowledge and competences able to exploit differences (individual, cultural, social and politics). This can be done with a set of fundamental knowledge and competences, in order to allow everybody to participate in the cultural network in an "expert" way. The attention moves therefore from teaching to learning: the focus is the individual with his/her horizontal, interactive, motivated learning, as a cocostructive actor of his/her own education and shared meanings. The cognitive activity is something that occurs not only *inside*, but also *among* the individual through exchanges that structure the reality and where the media have a fundamental role in the ongoing exchange. The learning process loses the connotation of private event and takes on the dimension of shared, distributed and conversational activity (Salomon, 1993; Sorrentino & Paganelli, 2006). ICT facilitate interaction and sharing, therefore also collective and connective intelligence processes, as well as knowledge and innovating communities: Internet seems like an "ongoing interbreeding factor among communities" (Calvani, 2005). Knowledge is framed following reticular, connective, horizontal schemes, able to activate dynamics of a concrete intelligence and, operating by trials and errors, through virtualization and interaction, it allows to plan new paths in training (Haughey & Anderson, 1998).

This is the main reason why all the individuals in training need to acquire—with the same level of command—a "toolbox" (computer literacy) which allows them to perform two important operations: the first is the use of specific knowledge-competences on complex, multi-faceted technological alphabets and tools, in order to fully understand media messages and experiences on the basis of a personal and creative point of view.

The second important operation is the use of specific critical and interpretative knowledge-competences, identifying the requests and the standardized models of the market found in media messages and experiences, in order to revise them on the basis of a personal, autonomous and critical point of view, thus regaining the fundamental freedom of choice and go beyond what is already given (which is worn-out, depersonalizing and standardizing). A common base for cultural literacy tools is the cornerstone of a school able to promote autonomous abilities of choice in the learning individual, that is, critical and creative abilities, both in a behavioral and in an ethical domain. However, together with educational equal opportunities, the educational system must take the commitment of promoting the most favourable educational conditions, in order to give all the students the opportunity of developing their own peculiar talent or intelligence. This is possible only if educational strategies are planned to allow every student to cultivate at his/her best his/her own talents and intelligences (*formae mentis*), presenting a clear differentiation of learning targets in relation with the specific cognitive abilities of the individual, between individualization and personalization (Cambi, 2004; Baldacci, 2005; Gardner, 1994).

To sum up, we need to go back to the etymological meaning of the word communication (from Latin *communicare*) which refers to "sharing" knowledge, emotions and thoughts by conveying messages. It is also important to emphasize the importance of being able to interact and reflect both with others and with oneself. A democratic and intentional teaching/learning process, therefore, is directed to the co-construction of knowledge, to the development of a critic and conscious thought in the individual, the promotion of a subjective identity and the creation of a variety of spaces where culture/s can meet and exchange and where it is possible to overcome communication barriers—cognitive, affective-emotional, cultural, linguistic—going towards educational options of autonomy, responsibility, commitment. A possible antidote against thought homologation, cultural levelling, ethic and civic commitment drift towards a new idea of a world citizenship, in a new Humanism and a new Renaissance (Margiotta 2005) is the creation of a virtuous and communicative circularity "open spiral", able to facilitate effective, welcoming, and generative communicative contexts, thanks also to ICT. We moved from the individual thought of the past to a more global thought, considered as a "community of minds" communicating—through a new connective thought (not centred on an individual learning and based on the integration between formal and informal learning)—which interact in the virtual world through open modalities of relation and communication based on writing, words, image.

The idea of a distributed and shared knowledge emerges, moving from the individual to the networks, from the individual to practices of social communities, from the individual to the collaborative practices of social networks. We must not forget, however, the urgent problem of the digital divide (OCSE-OECD 2001, 2004): technological and knowledge gaps among individuals, organizations and countries connected with their real opportunities (closely linked with various factors among which we can quote education, computer literacy, income, age, gender, English, geographical position and also the educational and economic national and international politics promoting equity and equality principles in practice) both in *accessing* ICT, in *using* Internet, and in *benefiting* from it. This poses again—and dramatically—the question of social exclusion of a large part of the population from knowledge sharing/creation.

Only by way of an example I will list a few among the most meaningful and concrete "open-tools" which can contribute in reducing the digital divide from the point of view of a solidly and equal opportunity information technology in accessing to knowledge: (1) Wikipedia, the huge free encyclopaedia on the internet, available in several languages and considered by many as "the new democratic border of knowledge", an encyclopaedia "from everybody and for everybody", with free contents, devised and created by Jimmy Wales in 2001; (2) Connexions, a project created in 1999 and launched in 2004 by Rice University – Texas, USA, with educational aims and supporting an approach based on communities of people willing to create teaching and learning contents, whose philosophy can be summarized in its slogan "create, rip, mix, burn". It is a corpus of small units of high quality information and learning which can be managed and used to create new teaching contents available on line and printable; (3) the OpenCourseWare program of the Massachusetts Institute of Technology (MIT), which makes available to teachers and students the materials of the prestigious courses in several subjects; (4) the Merlot project (Multimedia Educational Resource for Learning and Online Teaching) especially for its care in planning, production and description of the "fundamentals" (together with the possibility of print on demand, semantic description of content, import, branding, lenses). It is also important to point out the ease in collaborating among people who know and who can elaborate/transmit the information and the guarantee of open licenses as Creative Commons and General Public License (GPL, copyleft); (5) the GNU project, created by Richard Stallman in 1984 as a complete open and *free* operative system; (6) the Debian project developed in 1993, which stresses the issue of sharing and construction of knowledge *in* the community and *for* the community; (7) all the *free* software, more and more easily distributed, accessible, shared also thanks to the increasing use of cooperative development models.

If the Canadian sociologist and media scholar Marshall McLuhan, between the 1960s and 1970s of the last century, observing the "global village" stated that "the media is the message/massage", today we can say with, Lévy, that the role of information technology is that of facilitating the construction of intelligent collectives, where the social and cognitive potentialities of the individual can mutually develop and expand.

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KEY TERMS

Cyberculture: The culture that has emerge from the use of computers. It is a wide social and cultural movement closely linked to advanced information science and information technology and regards the social and cultural levels of human-computer interaction (between knowledge and lifelong learning).

Digital Divide: Gap between people who have regular, effective access to digital and information technology, and those without this access. It regards both physical access to technology hardware and skills and resources which allow to use it.

Distributed Knowledge: instructional model that allows instructor, students, and content to be located in different places (but they work, create, and learn together); instruction and learning occur independently of time and place.

E-Learning: Term used to refer to computer-enhanced learning, commonly associated with the field of advanced learning technology, which deals with both the technologies and associated methodologies in learning: e-learning 2.0, "Web 2.0" (between formal and informal e-learning, the Web and the personal learning environment).

Formal and Informal Learning: Formal learning is learning that takes place within a teacher-student intentional relationship, such as in a school system. Nonformal learning is organized learning outside the formal learning system, such as clubs, youth organizations, workshops (extra/out-school). Nevertheless, in the educational field, the main theoretical perspective promotes the idea of an "integrated educational system" (school system, family, extra-school educational and not-educational agency, mass-media, Web, etc.).

Learning Society: It is a society committed to active citizenship and equal opportunities. It aims at providing learning opportunities to educate adults to meet the challenges of change and citizenship, as well as the demands for the updating of skills and competences (in a lifelong learning perspective).

Social Network Practices: It refers to the process of social learning that occurs when people who have a common interest in some subject or problem collaborate to find solutions, build innovations, share ideas, and knowledge.

Leveraging Supply Chain Management in the Digital Economy

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INTRODUCTION

A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. In other words, supply chain encompasses all of the activities associated with moving goods from raw-materials stage through to the end user.

The information systems needed to monitor all of these activities are a critical part of the mix. Successful supply chain management (SCM), then, coordinates and integrates all of these activities into a seamless process. It embraces and links all of the partners in the chain. In addition to the key functional areas within the organization, these partners include vendors, carriers, third-party logistics companies, and information systems providers.

THE BUSINESS CASE FOR SUPPLY CHAIN MANAGEMENT

Improving supply chain management has become the major objective of the corporate world, because it represents an opportunity to resolve monumental problems that face corporations and create a mismatch between supply and demand throughout their supply chains.

For example, let us go back a few years to 1992, when a study of a major department store facing serious market-share troubles showed that 46% of the buyers who entered its stores that year did not buy anything! More than half of the empty-handed said it was not because they did not want something—they did, but the store did not have the product. The department store ended up with dissatisfied buyers and lost sales, plus a surplus of goods in stock that people did not buy, leading to mark downs. This is not a unique story. The number of markdowns among retailers have skyrocketed in the last decade, to the point where people refuse to buy unless goods are on sale and they totally distrust words like "suggested retail price".

This epidemic arises from a total mismatch of supply and demand. Customer and retailer and manufacturer alike are victims of "wrong product, wrong time, wrong place, and probably wrong price." It is a staggeringly costly problem. The retailer must support unwanted goods. The manufacturer must often deal with returns and a complex system of credits.

With constant markdowns, many retailers have faltered and ultimately gone out of business. The manufacturers have not been paid and there they sit with resources allocated to the wrong arenas. The mismatch between supply and demand ultimately arises from the inability of vendors and manufacturers, as their markets change, to make the right decisions about who they want to be. For instance, do the department stores want to be discounters, competing on the basis of commodity products? That is, all department stores would carry the same basic designer/manufacturing lines in clothing. Or do they want to differentiate themselves through such means as exclusive designers, private labels, and customer service?

Let us consider another example. Hewlett-Packard was historically known for high quality, high functionality products in computing and measurement that few, if any, could deliver. As these products became commoditized, customers expected HP to lower its prices, while maintaining a high level of functionality. In HP's case the transition has been from high quality and functionality at a premium price, to differentiation through a competitive combination of price, functionality, and delivery performance. The customer today is looking for a tradeoff: "Can you customize it for my requirements and can you deliver it reliably? And, oh, by the way, keep the price down" (http://www.internetsolutions.enterprise.hp.com/supplychain/library/articles/30000_feet.html).

The real challenge for companies, then, is to make the right decision about where they want to position

Figure 1. Products and services differentiate on price, functionality, and delivery performance

(Source: http://www.internetsolutions.enterprise.hp.com/supplychain/library/articles/30000_feet.html. 2000)

themselves in cost, functionality, and delivery performance with respect to both their customers' requirements and their competitors' strategies and gambits (see Figure 1). Companies can achieve this with better supply chain management.

Supply chain management involves the flows of material, information, and finance in a network consisting of customers, suppliers, manufacturers, and distributors. (Figure 2 gives an overview.) Material flows include both physical product flows from suppliers to customers through the chain and reverse flows via product returns, servicing, recycling, and disposal. Information flows involve order transmission and delivery status. Financial flows include credit terms, payment schedules, and consignment and title ownership arrangements.

These flows cut across multiple functions and areas both within a company and across companies (and sometimes industries). Coordination and integration of these flows within and across companies are critical to effective supply chain management. However managing these flows effectively is a daunting task, particularly for global corporations. A global corporation's supply chain now usually consists of multiple enterprises located around the world. Furthermore, each of these enterprises is involved in a wide variety of supply chain activities—order fulfillment, international procurement, acquisition of new information technology, and customer service. There are complex relationships such as multiple suppliers serving multiple customers, or a supplier who may be a customer or even a competitor in different parts of the chain. This complexity is why some people refer to supply chains as "supply networks" or "supply webs" (http://www.manufacturing.net/scl/scmr/scm0016/integration_1.html).

Executives of the various companies are increasingly recognizing the tremendous payoff of truly integrated supply chains. They read about Wal-Mart's leveraging of the chain to achieve a dominant position in the retail marketplace. They hear of companies like Dell Computer reconfiguring the supply chain to respond almost immediately to customized orders. They are intrigued by the bold measures taken by M&M Mars to virtually eliminate standing inventory from the pipeline.

The supply chain payoff can come in many forms. It might reduce transaction costs by eliminating unnecessary steps in moving product to market. It could enhance customer service through closer coordination among vendors upstream and carriers, distributors, and customers downstream. Or may be it increases market share within better customer service or lower costs.

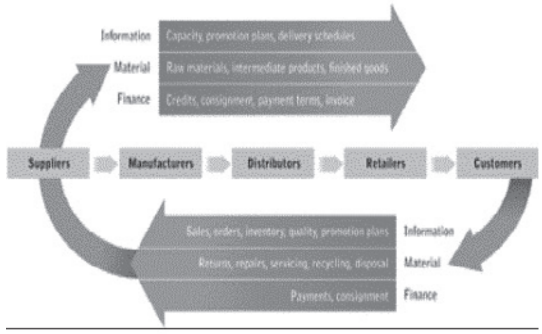
KEY CHARACTERISTICS AND PRINCIPLES OF SUPPLY CHAIN MANAGEMENT

The best supply chain management programs display certain common characteristics. For one, they focus intensely on actual customer demand. Instead of forcing into the market product that may or may not sell quickly (and thereby inviting high warehousing and inventory-carrying costs), they react to actual customer demand. And by doing so, the supply-chain leaders are able to minimize the flow of raw materials, finished product, and packaging materials at every point in the pipeline.

Andersen Consulting has encapsulated these qualities in what it terms the "Seven Principles" of supply chain management. When consistently and comprehensively followed, the consulting firm says, these principles lead to a host of competitive advantages—among them, enhanced revenues, tighter cost control, and more effective asset utilization. The seven principles are (http://www.ascet.com/ascet/wp/wpQuinn.html):

1. Segment customers based on service needs. Companies traditionally have grouped customers by industry, product, or trade channel and then

Figure 2. The supply chain flows (Source:www.manufacturing.net/scl/scmr/scm0016/integration_1.html)



provided the same level of service to everyone within a segment. Effective supply chain management, instead, groups customers by distinct service needs—regardless of industry—and then tailors services to those particular segments.

2. Customize the logistics network. Companies need to design their logistics network based on the service requirements and profitability of the customer segments identified. The conventional approach of creating a "monolithic" logistics network runs counter to successful supply chain management.
3. Listen to signals of market demand and plan accordingly. Sales and operations planning must span the entire chain to detect early warning signals of changing demand in ordering patterns, customer promotions, and so forth. This demand-intensive approach leads to more consistent forecasts and optimal resource allocation.
4. Differentiate product closer to the customer. Companies today no longer can afford to stockpile inventory to compensate for possible forecasting errors. Instead, they need to postpone product differentiation in the manufacturing process closer to actual consumer demand.
5. Strategically manage the sources of supply. By working closely with their key suppliers to reduce the overall costs of owning materials and services, supply chain leaders enhance margins both for themselves and their suppliers.
6. Develop a supply chain-wide technology strategy. Information technology must support multiple levels of decision making across the supply chain. The IT system also should afford a clear view of the flow of products, services, and information.
7. Adopt channel-spanning performance measures. Excellent supply chain measurement systems do more than just monitor internal functions. They adopt measures that apply to every link in the supply chain, incorporating both service and financial metrics.

To respond more accurately to actual customer demand and keep inventory to a minimum, leading companies have adopted a number of speed-to-market management techniques. The names by now have become part of the supply chain vernacular...Just in Time (JIT) manufacturing and distribution; efficient consumer response (ECR); vendor managed inventory (VMI); collaborative planning, forecasting, and replenishment (CPFR); cross docking; and more. These are the tools that help build a comprehensive supply chain structure.

The critical questions are: How do companies get to be supply chain leaders? What are the challenges involved in the process of implementation?

An essential first step is to integrate the key internal organizational functions that are involved in moving product to market. But, advancing from a highly segmented structure to a cross-functional team orientation can be a formidable challenge; people are inherently resistant to change. But, as the industry leaders have demonstrated, making that essential transition pays handsome dividends in terms of cost reduction, operational efficiency, and customer satisfaction.

Once the internal integration is underway companies can set their sights on the next challenge--executing the supply chain strategy and building the bridges to the external partners. This is not an easy task, even for the best-run organizations. It takes a dedicated effort and committed people who know the meaning of persistence.

A STRATEGIC SUPPLY CHAIN AGENDA: INTENT AND IMPLEMENTATION

The consulting firm of A.T. Kearney has developed an instructive framework for setting—and then implementing—a strategic supply chain agenda. The consultants recommend that a supply chain assessment team be created to spearhead the effort. Under the team's guidance, the agenda-setting process would proceed along four steps. (http://www.ascet.com/ascet/wp/wpQuinn.html)

1. **Assess the organization's supply-chain competitiveness.** The evaluation begins by comparing business objectives to existing capabilities and performance. This exercise typically reveals where the existing supply chain can achieve immediate competitive advantage (the "low-hanging" fruit) and where inefficiencies may be leaving the company vulnerable to the competition.
2. **Create a vision of the desired supply chain.** Through a series of "visioneering" sessions that include key customers and suppliers, the team considers how such trends as globalization, channel shifts, and new technology will affect the desired supply chain configuration. It addresses questions such as, what supply chain factors and performance levels drive customer buying decisions? What would make one supply chain a winner over others?
3. **Define those actions required to close the gap between tomorrow's vision and today's reality.** The team identifies possible re-engineering, restructuring, or other actions that could help narrow any gaps. At this stage, the team also works closely with management to assess the organization's readiness to pursue needed changes.
4. **Prioritize the action items identified and then commit the appropriate resources.** The end result of this task should be a unified commitment to a supply chain strategy and a clear agenda to achieve that strategy.

Subsequent actions to implement the supply-chain agenda typically fall into these broad categories:

- Designing the long-term supply chain structure to position the company in the right roles in the right supply chains with the right customers and suppliers.
- Re-engineering supply chain processes to streamline product, information, and funds flow internally and externally.
- Reinforcing the supply chain's functional foundation by improving quality and productivity within operational areas such as warehousing, transportation, and fleet management.

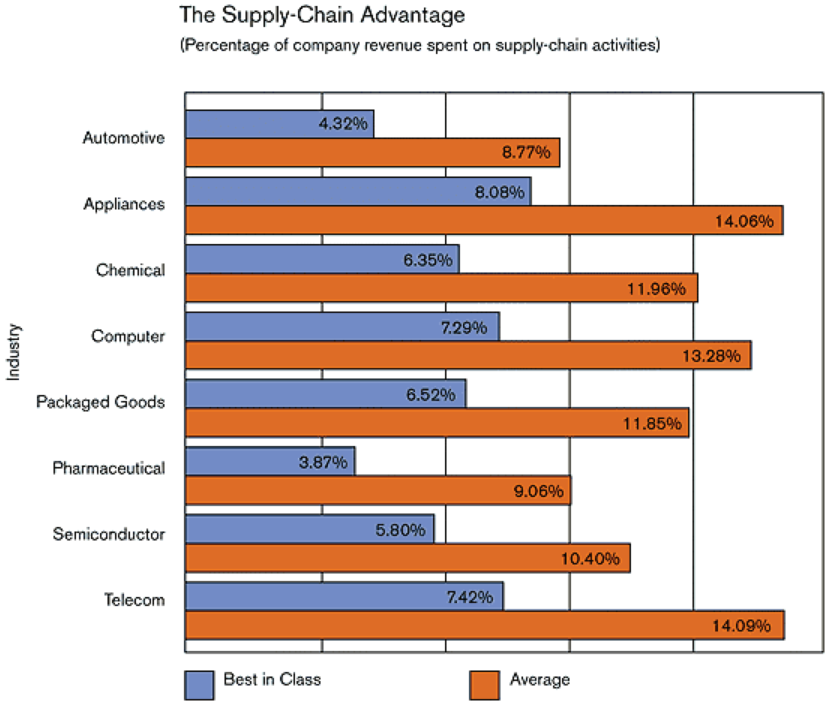
Ultimately, successful execution of this strategy will depend upon how effectively companies can integrate their operations with supply chain partners both upstream and downstream. As consultant James T. Morehouse of A.T. Kearney has pointed out in his writings and speeches, in tomorrow's market arena it will be supply chain vs. supply chain as opposed to company against company.

ANALYSIS OF PAYOFF OF SUCCESSFUL SUPPLY CHAIN MANAGEMENT

Given the extensive time, effort, and commitment of resources involved, is design and execution of a comprehensive supply-chain strategy really worth it all? An evaluation of the bottom-line numbers is the best way to respond to this question. According to A.T. Kearney's research, supply chain inefficiencies can waste up to 25% of a company's operating costs. With profit margins of only 3 to 4%, then, even a 5% reduction in supply-chain waste can double a company's profitability.

Through its comprehensive Integrated Supply Chain Benchmarking Study, Pittiglio Rabin Todd & McGrath

Figure 3. The supply chain advantage



(Source:http://www.ascet.com/ascet/wp/wpQuinn.html)

(PRTM) found that best practice supply chain management companies enjoyed a 45% total supply chain cost advantage over their median competitors. Specifically, their supply chain costs as a percentage of revenues were anywhere from 3 to 7% less than the median, depending on the industry (see Figure 3).

Based on his experience with companies participating in MIT's Integrated Supply Chain Management Program, Prof. Metz has identified certain commonly reported bottom-line benefits. These center on cost reductions in such areas as inventory management, transportation and warehousing, and packaging; improved service through techniques like time-based delivery and make-to-order; and enhanced revenues, which result from higher product availability and greater product customization.

There are other payoffs as well. For example, the supply chain technique of optimizing the distribution network—that is, determining the best location for each facility, setting the proper system configuration, and selecting the right carriers—can bring immediate cost advantages of 20 to 30%. That's the number determined by IBM's Wholesale Distribution Industry Segment, based on consulting engagements in a wide range of industries. "This typically breaks down into transportation savings of 15 to 25 percent and improvements in inventory-carrying costs of 10 to 15 percent," says Mark Wheeler, national solutions manager for the IBM consulting unit. (www.ascet.com/ascet/wp/wpQuinn.html)

Another supply chain technique with proven payback potential is cross-docking—the practice of receiving and processing goods for reshipment in the shortest time possible and with minimum handling. According to Maurice A. Trebuchon, a partner with PricewaterhouseCoopers, cross docking can produce savings of 25% or more over conventional warehousing. In a presentation made at the annual Council of Logistics Management meeting, Trebuchon cited one manufacturer that used cross docking to realize a net savings of $0.84 per ton of freight processed. The savings resulted from the elimination of putaway, picking, and storage costs.

CONCLUSION

In today's business world, one thing becomes strikingly clear: Supply-chain management is not just the wave of the future. For professionals working in this field, the issue is not so much whether to become expert in the art and science of supply-chain management, but rather how fast. This means becoming intimately familiar with the corporate mission and figuring out how supply chain processes can help achieve that mission. It means becoming an evangelist of the supply chain word—preaching both within the organization and externally to customers, suppliers, carriers, and third party logistics providers.

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KEYWORDS

Collaborative Planning, Forecasting and Replenishment (CPFR): Aims at the enhancement of supply chain integration by supporting and assisting joint practices. It seeks for cooperative management of inventory through joint visibility and replenishment of products throughout the supply chain. Information shared between suppliers and retailers aids in planning and satisfying customer demands through a supportive system of shared information.

Efficient Consumer Response (ECR): The joint trading and industry working towards a more efficient and productive answer to consumer demand and the removal of unnecessary costs from the supply chain. It's characterized by the emergence of collaborative management in the supply chain.

Supply Chain: A network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers.

Linking E-Assessment to Student's Use of Online Learning Content

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INTRODUCTION

This article will examine the development and implementation of two information and communications technology (ICT) e-assessment tools—a diagnostic assessment system and an intelligent content assessment marking system—for the teaching of secondary science. An e-learning management system (ELMS, see Figure 1) was used with second-year secondary students in science which provided both content and online assessment tools for teachers. By using this system, teachers had the opportunity to modify how they assessed their students by shifting the skills and knowledge being tested and also when and at which stage of the learning they are tested. The use of the ELMS had also assisted teachers to move away from the narrow confines of standardised tests with their discrete and decontextualized 'items' towards more complex, holistic, contextualised, and authentic forms of assessment (e.g., Pellegrino, Chudowski, & Glaser, 2001).

Using these diagnostic tools for assessment teachers could better help students gain mastery in specific content areas, in particular, the more abstract concepts in science education. The ELMS was used to collate the data from the two assessment tools and provided an additional online diagnostic profiling system (DPS). This profiling tool was then used by teachers to detect the extent and nature of each individual student's knowledge and competence within topics of study in order to help that learner progress ahead in developing independent mastery and lifelong learning skills.

CAPTURING THE POTENTIAL OF E-LEARNING AND E-ASSESSMENT

In schools where traditional assessment modes prevail, teachers are often swamped with setting and marking different forms of assessment, usually aimed at preparing students for high-stake examinations. In order for them to adequately assess which difficulties confronted by students impact learning most strongly, they need effective tools to develop ways and means to collect and analyse data in class. With the help of ICT tools, teachers can locate timely information about student learning which allows them to set meaningful and measurable goals for future learning. Assessment whether online or not can be used as one of the most powerful ways of improving learning. By simply changing the assessment of the subject, teachers can in turn affect the way students engage with the subject content (Black & Wiliam, 1998). New pedagogy is also needed to effectively leverage the use of technology. E-assessment cannot simply invent new technologies which recycle current ineffective practices (QCA, 2004).

As Conole (2004, p.3) pointed out, one of the affordances of ICT is the potential for multimodal and nonlinear approaches to navigating through information. She highlights the fact that the nonlinearity of the Web (epitomised by hypertext and the use of powerful search engines) leads to the potential for different routes through, and forms of, learning. Yet many research studies have concluded that much of the current online training materials still appear to follow a linear, assembly line mode of learning. Many 'e-learning' packages are built on behaviourist principles of atomised experiences that need to be completed in a specified order before the individual is positively reinforced and permitted to move on—a form of electronic page-turning (Conole, 2004).

When designing online learning systems, the structure of how learning content is incorporated is vital to its success. According to Boettcher (2003), course content—the material to be learned or studied—is only one of the four key core components of the learning experience. The other three are the *teaching*, the *learner*, and the *environmental* components. In her research, she emphasized that online learning based on well-structured content can impact the identification, selection, and development of course content in three ways:

- Content must be semantically well-structured for instruction; this corresponds to the *teaching* component of the learning experience.
- Content must be a good fit or well-structured for a particular student; this corresponds to the *learner* component of the learning experience.
- Content must be technologically well structured; this corresponds to the *environmental* component of the learning experience.

Boettcher extends this notion well beyond the dictionary meaning of well-structured content. It includes the nuances of interaction with the other three components of the learning experience—teaching, learner, and environmental.

Therefore, in practice, when researchers work with teachers and students in schools, how can course content be sufficiently well-structured to be really meaningful to the students? Just as being an expert in teaching science is not by itself a guarantee of good pedagogy, any ICT technology tools might miss the mark if they are not fine-tuned to the content the teacher wishes to present. It is well established that how the tools are being used is more important than whether the students and teachers like them. Therefore, when designing content for online delivery, teachers, instructional designers, and other stakeholders need to actively investigate and formulate their own strategies on e-learning as well as how to apply ICT tools to e-assess students.

With the emergence of online technologies as a new space for instruction, a lot of research has been conducted on the effectiveness of the teaching and learning process rather than on what students are doing within the learning experience. The organization of what is being taught and how content is being taught and assessed online—the structure of the course content and associated tools used to evaluate learning gain—have received much less attention.

Meanwhile, content development has certainly not been neglected. Large amounts of funds have been spent on developing digital libraries, learning objects, and online learning systems. These are all efforts that foster the evolution of learning management systems and tools for easy mounting of content and access to such content resources. There is clearly a trend for governments worldwide to continue further development of knowledge repositories at all levels of education. However, putting content online or packaging them as learning objects does not in itself guarantee the quality of teaching and learning. It may help students access learning opportunities, but it is unlikely to prove acceptable unless online learning is carefully and appropriately designed and structured to assess learning outcomes. Online learning materials cannot be stand-alone units; they have to blend in with teaching, learning, and assessment strategies.

Within the context described above, the main purpose of the article is to present the framework used for content creation when developing the online learning system which incorporated technology tools to facilitate a better understanding of profiles of student learning and the effective use of e-assessment. The framework established from this implementation guides us to understand how to utilize ICT tools and capabilities to enhance online learners' abilities to acquire knowledge through experiencing the process of guided e-assessment.

One critical factor for designing appropriate student-centered e-learning is to understand how students actually interact with the content and the ELMS. Another critical factor is: how can the ELMS develop and provide a profile of each student's learning which in turn allows teachers to attend to student learning deficiencies? The diagnostic assessment and content marking tools integrated in the ELMS presented in this article help to raise fundamental questions about the whole learning and teaching process. This is a process which needs continual research if we are to achieve the desired goal of maximizing the potential technologies offer to improve learning, teaching, and assessment.

EMBEDDING E-ASSESSMENT WITHIN THE ELMS

According to Bransford, Brown, and Cocking (2000, p. 12), active learning is where students take control of their learning by recognizing when they understand and when they need more information. To achieve this metacognition, new approaches to creating classroom environments must be employed and one key aspect of this change involves assessment. Pachler and Byrom (1999) stated that:

The nature of assessment of and through ICT sits ill-at-ease with traditional educational paradigms of testing the retention, recall and understanding of knowledge by individual learners compared with the more skill- and application-based collaborative modes supported by and intrinsic to working with ICT.…it seems therefore, that assessment paradigms will need to evolve in the light of emerging technologies and the learning objectives they predicate. (p. 127)

Black and Wiliam (1998a) have presented rather convincing evidence that formative assessment can lead to improvement in student learning. Yet, Black and Wiliam (1998b) also noted that such practice is rarely found in classroom teaching.

In a review of literature from 1994–2002, Webb and Cox (2004) concluded that ICT in secondary science, particularly in the form of simulations or animations of processes, provides a range of affordances for learning science. However, they went on to say that 'teachers do need to understand the affordances provided by the various types of ICT so that they can select ICT to meet their teaching objectives' (p. 258). They contended that 'much more significant changes in teachers' pedagogical practices would be needed to support a curriculum that was to take full advantage of the range of affordances provided by ICT and where more opportunities for student collaboration and student control of the learning are available' (p. 258).

High stakes assessment systems have perpetuated mainly because they have defined what is rewarded by a culture for many years. Current practice in schools means that teachers are swamped with setting and marking different forms of assessment which do not necessarily lead to better learning. To effectively integrate ICT in schools, teachers must consider integration issues into both the curriculum and assessment. Teachers need to reconsider the assessment approaches as there may be a greater role for formative assessment when ICT was integrated with the assessment process.

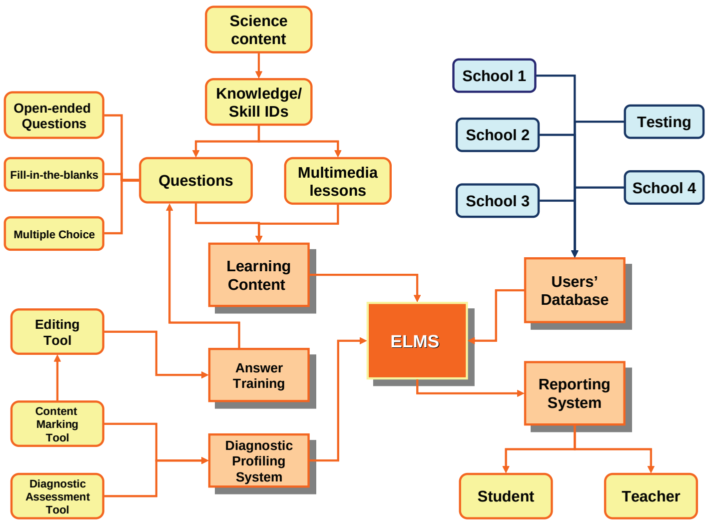
THE ELMS AND ASSOCIATED TOOLS

Within the ELMS (Figure 1), e-assessment methods were used to deliver much needed benefits to learners and alleviated the problem of lack of teacher time. The system provided immediate feedback for on-demand tests and quizzes. Simultaneous diagnostic feedback was also given to guide students to areas of weakness which needed remediation. Tests and other formative assessment items were delivered to students on a needs basis and completed as appropriate. Within the system, teachers could modify how they assessed their students by shifting the skills and knowledge being tested and also decide when and at which stage of the learning they were tested.

Throughout the preparation phase of the ELMS, consultations were held with all the stakeholders (teachers, principals, education authorities). This resulted in a radical redesign of the content and assessment tasks incorporated in the ELMS with the aim to stimulating student interest. Scenarios and game-based environments were used throughout. Both formative and summative assessment modes were facilitated by the diagnostic and content marking tools. These tools provided immediate feedback to both students and teachers on the students' abilities to grasp the concepts, and actually produced a profile (via the DPS) on a student's weak knowledge areas. The ELMS would then automatically customize a set of activities which were subsequently presented to students to improve the weak areas identified.

For students, the ELMS offered many benefits over traditional assessment modes. These benefits included attention to a greater range of important learning outcomes, opportunity for contextualized and authentic assessment, integration of formative feedback for improvement, and generation of an achievement profile over time rather than on a single occasion. Teachers gained valuable experience from ongoing professional discourse where they compared their assessments of students and moderated their judgments against common benchmarks of learning outcomes. This provided an excellent opportunity for improving and modifying

Figure 1. E-learning management system (ELMS)



their own practice purely based on professional motivation and not on any official sanctions.

THE E-ASSESSMENT TOOLS WITHIN THE ELMS

Teachers were asked to explicitly identify the type of science problems that a student found difficult to solve. Based on this information, high-quality, interactive component lessons were developed which comprised a suite of teaching and learning content based on the diagnostic capabilities of the diagnostic and content marking systems which would allow students to engage in learning in new ways. Great care was taken when designing the interactive materials to ensure that students could achieve a deeper mental interaction with the content. Through simulations, students would need to grapple with ideas, make decisions, and choose directions when given options to consider.

In order to alleviate the problem of time, substantial resources were produced which comprised usable learning objects that could be used to strengthen teaching and learning activities. Appropriate content was integrated into curricula so teachers had more time to monitor and assess actual student learning. In no way was the ELMS meant to comprise isolated pieces of specialized software that allowed teachers to 'teach' science per se. It was a complete learning environment that facilitated meaningful professional thinking and working. Through this tool, teachers could use the reusable learning objects and the environment to engage their students in critical thinking and to help further their own professional development concerning aspects of assessment. The online curriculum content provided teachers with interactive learning activities which included text, graphics, audio, and animation which were linked to the specified science skills framework. Such materials were purposefully designed to exploit the use of online tools to enhance students' learning experiences. These learning objects existed as either one or more files or 'chunks' of learning material which may be used in multiple contexts for multiple purposes. The learning objects could also be used as components of a topic or unit of work alongside other digital and nondigital resources and tools. To provide meaningful data for teacher analysis, each of the specified science skills as portrayed in official curriculum documents were explicitly identified and coded and accessed by their metadata descriptors.

The Diagnostic Tool

Within the ELMS, teachers had use of two major assessment and diagnostics tools, which fed data into the diagnostic profiling system. When data was collected by the diagnostic and content marking systems, teachers could then access the DPS to obtain a continuous profile of students' abilities on the specific subjects or topics. Teachers could easily monitor students over a period of time and keep historical records, thus enabling them to see areas of strength and weakness of individual students or classes at any time of the year for each subject topic. With this information, they could plan future lessons or carry out revision accordingly. This successfully eliminated the current practice where teachers were only able to know pupils strengths and weaknesses after several months or after each manual test or exam.

The diagnostic assessment system is an innovative tool that intelligently identifies the specific strengths and weaknesses of individual students throughout each topic's relevant lesson and automatically prompts component lessons for remediation in weak areas. It is Web-based and aims to add value to the teaching and learning process of students and make learning more effective and efficient. Access via the Internet also enables students to access the resources outside their classrooms (e.g., homes). This tool instigates a complete learning cycle (Figure 2) by replicating the teaching and learning process while automating the performance feedback mechanism. It does so by empowering the learner to engage in self-learning through the Web on any subject, for example, science (as is the case for this project).

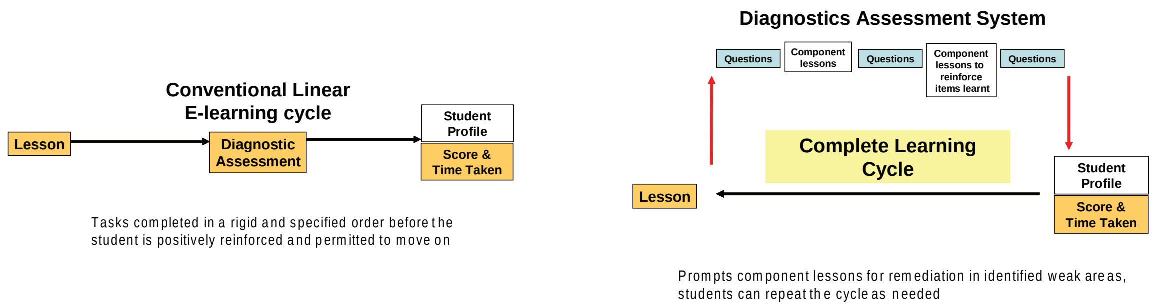
The predict–observe–explain learning cycle was employed for each topic where students had to engage in three tasks. First, they *predict* the outcome, and then they *observe* the event (simulated experiment online) and describe what they see and finally they *explain* any conflict between their initial prediction and final observation. Using this process, the students' thinking processes were made explicit and, at the same time, documented by the ELMS for later analysis by the teacher.

The ELMS could be used in class to supplement face-to-face teaching. It could also be used by students for individual self-learning through repetition without the presence of the teacher, as the system can be accessed from home. On the one hand, it provided opportunities for students to be independent learners. On the other hand, it offered an opportunity for schools to embark on and create an e-learning culture through learning and teaching via the Internet. Through this approach, students were exposed not only to quality content but also given the chance to experience knowledge acquisition in a different mode, an important process in the overall objective of the current education reform agenda.

The Content Marking Tool

The content marking tool is able to mark open-ended content like short and paragraph answers for subjects like science where the content that does not require writing style as a criterion for performance. This system is

Figure 2. Conventional linear vs. complete learning cycle



also able to classify and group various students' answers, especially nonstandard, creative answers. With the use of this tool, online learning is no longer constrained to conventional inputs such as multiple-choice and fill-in-the-blank questions. This tool can mark thousands of open-ended answers instantaneously and provide feedback to students as they learn.

The Diagnostic Profiling System: Tools for Formative and Summative Assessment of Individual Students

The diagnostic and content marking tools engage students in a complete learning cycle comprising multimedia lessons, diagnostic tests, component lessons, and remediation activities. Data collected with these tools are then combined to reveal each student's degree of learning through the diagnostic profiling system (DPS). At the system level, teachers are provided with:

- Instantaneous and meaningful feedback to students;
- Removal of time lag for teacher feedback to students;
- Significant reduction in marking load for teachers, freeing up time for them to focus on diagnostic and assessment strategies;
- Provide historical records of student diagnostics—individual, class, or level;

Once the answers have been marked, the system can automatically tabulate all the marks of each student after the new marking scheme (after step 4 has been completed) has been set and saved. In this manner, the teacher does not have to mark every script. All the teacher has to do is sieve out all the creative or unacceptable answers and allocate the marks that need to be rewarded for correct or partially correct answers.

Advantages of the Student Profiling System

The student profiling system (DPS) collates each student's answer and allows the teachers to monitor the performance of each student. In addition to the teacher, coordinators or subject committees can gather real-time statistics of all students' performance. Since each skill is tagged, specific skills and subskills attached to the questions within topics can assist the teacher to more closely evaluate and assess the students on their literal, interpretive, or applied skills. As and when needed, reports can be generated to provide a profile with clear diagnostics of areas of weakness or strength as depicted in the boxes in the righthand column (Figure 3).

With regard to teaching and learning science, Linn (2004) found that 'students do not connect their views, they fail to generalize their ideas to new problems, and they often cannot recognise problems that closely resemble those they have studied' (p. 345). They maintained that 'too often assessments tend to reinforce piecemeal science learning' (p. 345). In order to avoid this, the ELMS was designed to give students a low threat environment where they can be provided a second and third chance learning. In this study, students could work with the ELMS in three ways:

- The teacher teaches the topic in a face-to-face classroom situation, and students are then asked to complete the assessment tasks in class;
- After the topic has been covered in class, students can access the system at any time and work on the assessments tasks to further consolidate their skills and knowledge and be guided through the learning according to their level of ability; and
- Students can attempt the topics, questions, and component lessons totally on their own or for revision purposes.

Table 1. Actions taken by teachers to train the answers in the ELMS

Steps	Action by Teachers
1	Teachers input model answers for each topic and allocate marking scheme
2	Students complete the topics and input individual answers
3	Teachers go over the answers from students and decide on marking scheme for those answers not already in the system
4	All answers consolidated back into the system for future use

Figure 3. Strengths and weaknesses of each skill diagnosed for individual students to facilitate remediation

Strength of Each Skill Diagnosed

Topic	Skill	Score	No. of questions	Ability
Making Use of Electricity	Understand current is measured using Ammeters	7/9	9	Excellent
Making Use of Electricity	Investigate how a current flows through a closed circuit, with the presence of a source of electrical energy	7/9	9	Excellent
Making Use of Electricity	Investigate how a current flow in a closed circuit to light up a bulb.	6/12	12	Weak
Making Use of Electricity	Classify objects into electrical insulators and conductors	5/9	9	Average
Making Use of Electricity	Explain what is meant by the term current	7/9	9	Excellent
Making Use of Electricity	State the unit and symbol of current	3/3	3	Excellent

[Back]

As discussed earlier, the diagnostic and content marking tools can track iterative improvements using embedded assessments. This degree of flexibility afforded to students means that the ELMS can play a crucial role in assessment, and at the same time, teachers can continually redesign instruction to better cater for students' differing learning styles.

The ELMS provided an assessment system that integrated formative feedback and adaptive learning programmes. Given the administrative overload that many teachers are experiencing, it is providing teachers with the tools needed to intelligently automate assessment (Davitt, 2005). Using the ELMS, teacher can obtain a personalized learning profile for each student by tracking progress in each area against learning targets. As Figure 4 indicates, at any stage, students and teachers can review their learning progress in each area.

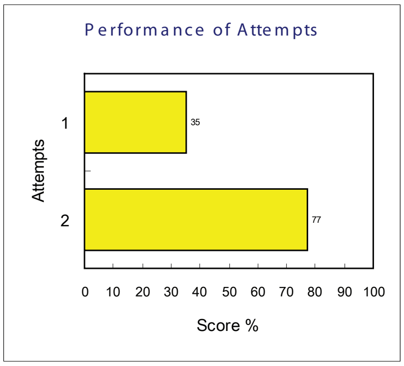
Students completing the tasks were guided by the system to e-learning applications which were personalized and provided instantaneous feedback to the students at appropriate times. Depending on the level of students' abilities in completing the tasks, the ELMS was able to provide individual users with a navigational path that guided their learning. Results from the trials show that when students make more attempts at learning by repeating the learning cycle several times, they actually improved. For some topics, after five attempts, students were able to score 100%. Figure 4 shows how students were able to improve their score after several attempts.

LIMITATIONS AND ISSUES

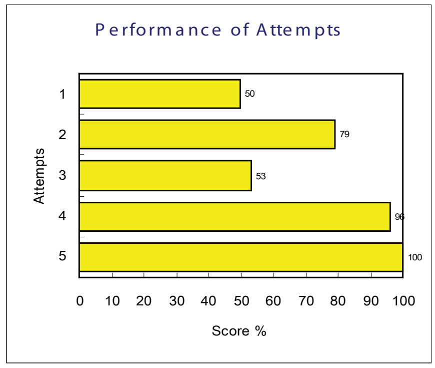
This article has provided an account of how a curriculum innovation project was conducted in secondary schools to establish a valid and reliable online measuring tool for knowledge components and problem-solving skills when learning science. Information is also provided on how the use of two online tools can assist students to engage with more cognitively demanding computer-based curricula to achieve enhanced learning outcomes. The experience from this project correlates with research findings which indicate that technology supported innovative classroom practices can help to change classroom teaching and learning (Kosma, 2003; Lee, 2002; Means, Penual, & Padilla, 2001; Schofield & Davidson, 2001). When teachers are stretched and required to collaborate with outside actors, they begin to see the potential use of technology well beyond their normal expectations. They begin to use technology differently and accept the fact that their students will also use technology differently. Both these changes in classroom practice demonstrate the possibilities of how curriculum can be delivered and how technology can be used in a more integrated ways to achieve desired learning outcomes.

However, in reality we found that students often found it difficult to meet the challenges and to engage in logical reasoning, particularly in the form of simulations or animations of processes specifically designed to measure the degree of learning. This is an area where students need a lot of teacher support. As Webb and

Figure 4. Student performance improved when more attempts at learning were made



Performance increased from 35% to 77% after two attempts



Performance increased for students: after five attempts students scored 100% on the assessment tasks

Cox (2004) had emphasized, ICT in secondary science does provide a range of affordances for learning science. However, they cautioned that teachers do need to understand the affordances provided so that they can select ICT to meet their teaching objectives (Webb & Cox, 2004, p.258). It is also very important for teachers to be aware of their students' beliefs in relation to their degree of control of their learning, and they need to understand the affordances for their particular students. It is only then that teachers will be able to plan activities that enable students to exercise control over their learning and to provide support or scaffolding when students need it (p. 274).

The experience gained from this implementation is in accord with a model for assessment presented in a NCR report, Knowing What Students Know: The Science and Design of Educational Assessments (Pelligrino, Chudowsky, & Glaser, 2001). In this report, it is argued that an improved educational assessment system ought to connect the three key elements of an assessment triangle: cognition, observation, and interpretation: The cognition leg of the assessment triangle is a 'model of student cognition and learning in the domain' (p. 296). Report authors contend further that 'assessments need to examine how well students engage in communicative practices appropriate to a domain of knowledge and skill, what they understand about those practices, and how well they use the tools appropriate to that domain' (p. 92).

There is, in any event, further scope for research that would need to identify innovation in teaching methodology prompted by the unique features of the diagnostic assessment and content marking tools particularly moving in the direction of more student-centered methods and how they impact student learning. For this implantation, the expectations of our research clashed somewhat with teacher beliefs because they had the tendency towards conservative teaching styles. Our expectations for the manner of engagement of students emphasized thinking and discussion, but this again did not match the student expectations as it was foreign to them.

The development of e-learning and e-assessment has provided an essential step forward for use of ICTs in schools. The outcomes from this implementation provide important insights into the use of these tools, and it can be concluded that there is a need to (1) provide a wider range of question formats; (2) encourage students to be more self-directed and control their own learning online; (3) encourage teachers to make significant changes to their pedagogical practices, and (4) continually refine and enhance the intelligence level of the marking system by achieving critical mass input of answers. Our view is that for the ELMS to be effective, all students and teachers need to experience it on an ongoing basis before they can fully appreciate its value and benefits.

ACKNOWLEDGMENT

The ELMS and associated tools were proprietary tools developed by Litespeed Pte Ltd. The implementation was supported by a grant from the Quality Education Fund, Education and Manpower Bureau, Hong Kong.

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KEY TERMS

Content Marking Tool: A technology that is able to mark open-ended content like short and paragraph answers for subjects like science and any other content that does not require writing style as a criterion for performance. This system is also able to classify and group various students' answers especially nonstandard (creative answers) to facilitate immediate classroom discussions.

Diagnostic Profiling System: A tool that intelligently identifies the gaps in student understanding. Where required, the diagnostic process can automatically trigger appropriate learning resources to help the learner start to address any gaps that might have been identified. It is Web-based and facilitates self-paced learning via a complete learning cycle which replicates the teaching and learning process while automating the performance feedback mechanism.

E-Assessment: Refers to on-demand testing to cater for students who learn at different rates; assessment is provided in a timely manner and is adaptive in nature. It includes automating administrative procedures relating

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to assessment tasks and digitizing content for online testing which ranges from multiple choice tests to interactive assessments of problem-solving skills.

E-Learning Management System: An electronic environment that enables the delivery, management, and administration of a range of learning activities, services, content, and data to better cater for students' learning needs.

Management Information System in Higher Education

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INTRODUCTION

The communication and implementation of a strategic plan is typically based on various measures in educational institutions. The balanced scorecard approach has in the 1990s attained an important role worldwide in private and public sector organisations. Large organisations have different organisational levels, where it is useful to apply the balanced scorecard. This emphasises the need for the automation of the measuring system. The information is typically collected from various data sources. These characteristics underline the need to plan a management information system (MIS) to support the management process.

Strategic management is bridge building between the perceived present situation and the desired future situation (West-Burnham, 1994; Wheale, 1991). Strategic management involves taking stock of the educational policy, local economy, and other factors in the organisation's environment. It adapts the organisation to its environment but, on the other hand, tries to exert a positive effect on the development of its local community (Bush & Coleman, 2000; Kettunen, 2003; Middlewood & Lumby, 1998).

The balanced scorecard approach developed by Kaplan and Norton (1996, 2001) is an approach to communicate and implement the strategic plan. The approach creates strategic awareness among the management and members of the organisation and translates the strategy into tangible objectives and measures. It also aligns the strategies of different administrative units and aggregates the lower organisational levels to the upper levels. If the MIS does not support management, the introduction of the balanced scorecard is easily left halfway finished.

The purpose of this article is to show how the MIS can be planned to support the management process using the balanced scorecard approach. An example is given from the Turku University of Applied Sciences (TUAS), which introduced the balanced scorecard in 2002. The entire management process was described in 2004, and the MIS was implemented from 2004-2006. The development project is clearly strategic because it directly supports and shapes the competitive strategy of an organisation as explained by Remenyi (1990). The new system is also open to the personnel, which enhances strategic dialogue and supports the commitment of the personnel to the chosen strategic outlines.

BACKGROUND

The balanced scorecard approach translates the strategy into objectives and places them typically in four different perspectives:

- Customer
- Finance
- Internal processes
- Learning

Each objective placed in the perspectives is described by the measures, and their target values are typically set for several years. The management of an organisation sets the objectives, measures, and targets for the organisational units responsible. The MIS is planned to support the balanced scorecard approach.

When the balanced scorecard approach was introduced in 2002 at the TUAS, it was evident that utilising the new management tool properly would require a more sophisticated information system. The first difficulty was the ambiguity of measures in applying the balanced scorecard. The interpretability was high because the content and definitions of measures were ambiguous. This inhibits reliance on strategic management. The second difficulty was the manual maintenance, which required automation to be reliable and efficient. The data could not be directly transferred from the basic data sources. The use of measures combining data from several basic systems needed manual calculation, which was not reasonable in a large organisation.

Management in a knowledge intensive organisation applying the balanced scorecard requires organised and controlled information technology architecture. The data warehousing approach was selected to provide an integrated database. This integrates data derived from various data sources. It is an effective means of handling the large amounts of data needed in the management process. A management portal was planned to utilise the data warehouse, support the management process, and communicate the implementation of the strategy throughout the institution.

Our experience shows that the balanced scorecard may easily be an insufficient tool to communicate and implement the strategic plan due to troublesome calculation and unreliable measures. A proper MIS is necessary in large organisations having many organisational levels. A proper MIS presupposes modeling and developing the entire management process and tailoring the information system to meet the specific needs of the organisation.

MAIN FOCUS OF THE ARTICLE

E-Management Portal in Higher Education

Figure 1 describes the architecture of the academic MIS including the e-management portal. The management process is at the top of the hierarchy. The academic management portal and the data architecture are designed to build the MIS. The management and personnel of the organisation use the management portal. It utilises data from the data warehouse, where existing data on the various operational data systems are collected.

The balanced scorecard approach was introduced at the TUAS in 2002 without any specific information system designed for the new management approach (Kettunen, 2003, 2005; Kettunen & Kantola, 2005). It is important that the strategic planning with all the necessary elements of implementation should permeate all the levels of the organisation from the overall institutional level to the degree programmes and individual employees. The balanced scorecard approach has not been properly introduced if the existing information systems do not directly support it. This was one of the main reasons for initiating the project of the new MIS with a portal at the beginning of 2004.

The description of the management process is a necessary phase because it facilitates the time tables so that they take into account the steering of the Ministry of Education, the budgeting process of the institution, and the internal target negotiations between the rector and administrative units of the institution. The detailed description of the management process produced a large sheet, which was put on a wall. About 700 concepts were defined at the different levels of the organisation for the information system.

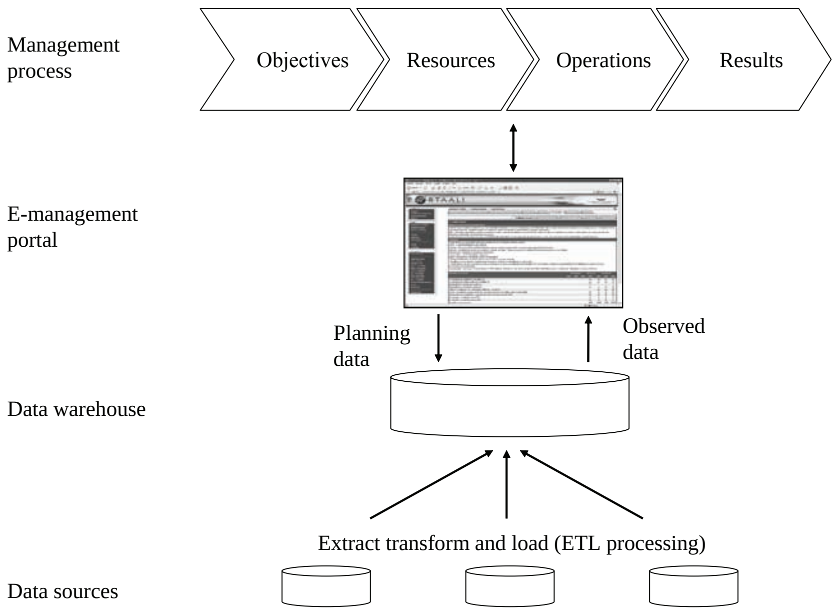
The management process includes the following sequences of main activities:

- **Objectives:** Strategic planning produces strategic objectives. It is important that the capabilities of the personnel are taken into account to define the objectives in the learning perspective. The other objectives must also be defined consistently in relation to each other.
- **Operations:** The operations of the internal processes are planned to achieve the strategic objectives.
- **Resources:** Financial resources are allocated in the budgeting process for the operations to achieve the strategic objectives.
- **Results:** Operations are performed to achieve the desired objectives within an agreed time and budget.

The elements of the management process should be consistent with the objectives and their causal relationships defined in the balanced scorecard approach.

The e-management portal was developed to support the management system. The concept of the portal refers to an access to information and services in the net (Rose, 2003; Smith, 2004; White, 2000; Zhou, 2003). The management will require that the persons at the different organisational levels use the portal of the MIS. Individuals have diverse user rights and roles in the portal. The portal has electronic forms, which allow different organisational units to draft their strategic and action plans, budgets, workload plans, and reports. The portal also has software for project management. The strategic development framework of the portal enables the automation of the management process. The documents of the portal help the administrators to communicate the strategic objectives and targets of the measures.

Figure 1. Architecture of the management information system



The data warehouse is a collection of data received from the existing operational systems (Guan, Nunez, & Welsh, 2006; Inmon, 1996). The operational data systems provide information about the performance of the organisation. The planning information produced by management is also stored to the data warehouse. The data warehouse is a consistent, consolidated, and refined information collection that integrates different data sources. The task of the data warehouse is to produce diverse reports, statistics, and analyses based on the data from the operational systems and the information produced in the portal.

The data warehouse of the TUAS integrates data from three operational data systems: the accounting system, the human resources system, and the study management system. There are also plans to integrate the project management system and the workload planning system into the data warehouse in the future. The integrated systems provide the basic data of the functioning of the organisation. The raw data from these systems are extracted, transformed to a consistent and recognizable form, and then loaded into multidimensional information cubes at the data warehouse (ETL processing).

The information system also receives input produced in the portal during the management process. This information includes strategic and action plans, the target values of the measures, budgets, and the human resources planning of the organisational units. The system aggregates the plans and budgets of the units on the level of the organisation and stores the information to be compared with the transaction data in the future. This information is connected to the procedural knowledge of the e-management portal.

Table 1 describes the people's involvement and their roles and functions in the MIS, including the balanced scorecard. The role of top management is strategic planning and the implementation of strategic plans with middle management and other personnel. The measures of the balanced scorecards describe the implementation of the strategy. The target values of the measures are agreed in the internal strategic negotiations between top and middle management. The development manager helps top management with the planning and support of the portal and the planning of measures. The information service coordinator assumes responsibility for providing reliable data obtained from the basic data sources. The system does not require any additional activities of the personnel but provides them with more information on how the information they produce in accounting, student and personnel administration, and other activities used in management.

Table 1. People involvement in the MIS

Persons	Roles and functions	Balanced Scorecard
Top management	Strategic planning and the implementation of strategic plans	Selection of measures and setting target values for the planning period
Middle management	Operative management	Proposition of target values based on the action plan
Development manager	Portal planning and support	Planning of measures with top management
Information service coordinator	Provision of information needed	Collection of data from data sources for data warehouse
Personnel	Using basic information systems	Input of reliable data to the data sources

FUTURE TRENDS

Management Using the MIS

The MIS based on the balanced scorecard is a management tool to be used at all organisational levels. User roles have been specified for the individuals' organisational positions. Different roles enable users to observe different views and allow them to accomplish the tasks that have been defined for the user roles in process descriptions and instructions. The system issues reminders about the tasks which need to be done.

All the organisational units prepare their strategic and action plans, budgets, and human resource plans using the portal. Each head of an organisational unit has the responsibility for preparing the plans for the three-year planning period. The system is open and has dialogue with the members of the personnel. The head of the unit submits the plans through the portal to the personnel, who may comment on these documents and suggest modifications and changes. Thereafter, the head of the unit revises the plans and submits them to the rector of the institution.

The MIS is used in strategic target negotiations using the portal. These negotiations are arranged between the rector's top management group and the management groups of the various organisational units. The rector typically makes a counter-offer to be discussed in the target negotiation. The plans of the organisational units are agreed, finalised, and saved in the portal. The plans of the units are aggregated to the overall organisational level. As a document archive, the portal is open to all the members of the organisation.

The reporting of the results is used to evaluate how the institution and its organisational units have been able to reach their strategic objectives and agreed target values of measures. The reports are based on the data obtained from the data warehouse and the qualitative information provided by the various organisational units. The information system also produces reports for the Ministry of Education, the owner of the institution, and for Statistics Finland.

Quality Assurance Using the MIS

The European Ministers responsible for higher education agreed in the Bologna Process on joint objectives for the development of a coherent and cohesive European Higher Education Area by 2010. The desired objective based on the Bologna Process is to make Europe "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth and with more and better jobs and greater social cohesion" (Berlin Communiqué, 2003).

The quality of higher education is at the heart of establishing a European Higher Education Area. The ministers responsible for higher education agreed in Berlin that the national quality assurance systems should be evaluated by 2010 (Berlin Communiqué, 2003). The national governments take the responsibility for establishing quality assurance systems for higher education. External quality assurance is based on peer review and evaluation. The quality assurance includes a verification that internal processes are appropriate to the purpose and have been appropriately applied.

A quality audit is a check to see whether the institution and its processes are adequately structured to achieve the strategic objectives (Woodhouse, 2003). Each higher education institution has the responsibility for quality assurance representing its academic and organisational autonomy. A proper MIS system can be a valuable tool in quality assurance. It describes the management process and quality assurance. It is also a document archive where the continuous improvement can be verified. The MIS is not only a document archive but integrates strategic management and quality assurance.

CONCLUSION

Strategic management has been widely used as a management system in various educational organisations. Even though the management processes are similar in different organisations, they also differ. Information systems are not equal in different organisations. Therefore, the MIS has to be tailored for each organisation. The experiences of this study show that the balanced scorecard is a useful basis for the MIS because it translates the strategic plan into objectives and tangible measures.

The MIS requires organised and controlled information technology architecture. The diverse data sources of an organisation form the basis for data warehousing. The data from various systems are extracted, transformed into consistent and recognizable form, and then loaded into the data warehouse. Data warehousing provides an integrated database to facilitate the technical infrastructure of management. It provides an effective means for handling the large amounts of data needed in various tasks of an organisation.

A portal of the MIS is a tool developed to support the management process and communicate the strategic objectives throughout the organisation. A useful MIS portal can be used with a Web browser and by all the members of the personnel. An advantage of this is that the members of the organisation can directly see how they can contribute to the organisation's strategic objectives and are committed to implementing the strategy. Data warehousing makes the collection and processing of data much more effective and reliable compared to the systems where the data are decentralised to different data systems.

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KEY TERMS

Balanced Scorecard: The Balanced Scorecard approach was developed to communicate and implement the strategic plan. The Balanced Scorecard approach translates the strategic plan into tangible objectives and measures and balances them typically into four different perspectives: customer, finance, internal processes and learning.

Data Warehouse: Data warehouse is a consistent, consolidated and refined information collection that integrates data from various data sources. The data warehouse produces information, reports and statistics for decision-making and other purposes.

E-Management Portal: An e-management portal is an electronic platform for the management process and quality assurance. The implementation of the strategic plan and the continuous improvement of quality assurance are described in the action plan of the portal.

ETL Processing, Extract Transform and Load Processing: The data from diverse data sources are extracted, transformed into consistent and recognizable form and then loaded into the data warehouse.

Higher Education Institution: Higher education institutions include typically traditional universities and in many countries professionally-oriented institutions known as universities of applied sciences or polytechnics.

Management Information System: A management information system presupposes modelling the entire management process of an organisation and tailoring all the necessary components of the information technology support system to meet its needs. The management information system should include a description of how the strategic objectives will be achieved and the necessary measures.

Management Process: The management process typically includes a sequence of management activities with the necessary descriptions. The main management activities include the definition of strategic objectives, operations of internal processes, allocation of resources and achievement of results.

Strategic Planning: Strategic planning involves taking a view of the long-term future planning with clearly articulated values, mission, vision and strategic objectives.

Mobile Learning and an Experience with Blended Mobile Learning

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INTRODUCTION

Pownell and Bailey (2001) identify four "technological trends" in the relationship between Information and Communication Technologies and educational environments. In the 1960s the first computers, which were very large and extremely expensive were rarely used in the educational area. They were only used to help in administration and in management. In the seventies with the arrival of the personal computer, schools in several countries, as in the United States, introduced computer basic courses to help students learn the use of this new technology. In the nineties the large-scale diffusion of Internet and the World Wide Web lead to a huge number of people who communicated through a computer mediated communication. At last in 2000, extremely small computers were sold on the market and the era of wireless connections began. These two factors in the educational field encouraged the beginning and the development of mobile learning.

BACKGROUND

With the term mobile learning, we refer to the modality of the distribution of almost any educational content, for example: entire traditional courses or new mini-courses, using mobile technologies such as Pocket PC, PDA (personal digital assistant), Table PC, eBook, mobile phones, and other portable devices.

Mobile learning is different from e-learning, since it is not just electronic, it is mobile (Shepherd, 2001). Mobile learning is seen as the natural evolution of e-learning, according to Hoppe, Joner, Millard, and Sharples (20003) "m-learning is e-learning using a mobile device and wireless transmission." Harris (2001) also writes, "m-learning is the point at which mobile computing and e-learning intersect to produce an anytime, anywhere learning experience."

With mobile learning the learning phase is not bound to a location with specific characteristics, potentially becoming omnipresent learning. For example, delays during commuting and traveling on the underground become potential learning moments. In general, any moment which would otherwise be "wasted" or that before now could not be enriched with didactic contents, has now become a potential learning moment thanks to mobile learning.

The privileged target of this new type of distance education typology will be made up of professionals who spend most of their time away from their work location and need updated information at the last moment; or for example, commuters who do not have time to keep updated if not the doing time it takes to ride to the office on the train or university students who also work.

Since 2000, studies and projects, which focalize on mobile learning, are increasing constantly. The MLEARN conference (the World Conference on Mobile Learning) held for the first time in 2002, has now become an annual event, as for example, the International workshop on Mobile and Wireless Technologies in Education (WMTE) and The National Workshops and Tutorials on Handheld Computers in Universities and Colleges, held in the United Kingdom. In Italy, apart from the third MLEARN conference held in 2004 near Rome, it is difficult to identify conferences or research groups that study this specific topic.

Many researchers, especially in the UK, Finland, North America, Chile, Japan and Taiwan have been and still are dealing with this new learning methodology.

Several authors subdivided the works presented in literature into research areas based on the arguments discussed. Specifically Hoppe, Joiner, Millard, and Sharples (2003) identified the following three research lines: "the first work group deals with the nature of the collaborative activity: how this favors or hinders learning, and the implications relative to the development of the mobile wireless technology for learning. The second work group reports studies regarding the innovative use of mobile wireless technology for learning. At last, the last series of work shows the innovative developments in the field of learning" (p. 256).

Trifonova and Ronchetti (2003) also have cataloged their research relative to m-learning on the basis of three macro areas: infrastructural research, accessing content and communicating and interacting with people.

In the first area, studies treat problems connected to navigating on the web with a device, such as a PDA with a very small screen. This area includes all of the studies relative to the techniques of adapting contents of Web pages to mobile devices.

The second area includes research relative to the adaptation of courses taught in e-learning to mobile learning, the creation of new courses from scratch, and finally also included in this group are the areas of study relative to the construction of WAP portals. For example, in this area there are several studies which are relative to the development of different systems for combining WAP courses with notification systems via SMS. These studies took place in different universities, of which the Griffith University Gold Coast where "HyWeb" was developed (Jones, Jo, & Cranitch, 2002) and the Minnesota State University where Virtanen, John, and Wright (2002) developed "mid2000".

Finally, the last area contains all of the studies on communications and interactions. Interaction can be limited (for example: as only an exchange of messages) or it can be very structured. In both cases, as Trifonova and Ronchetti (2003) evidenced, technology has a lot to offer. Experiments based on the simplest interactions were conducted by Stone, Briggs, and Smith (2002) and Stone and Briggs (2002) at Kingston University. Experiments based on very structured interactions were studied in the Norwegian project KNOWMOBILE (Smørdal, Gregory & Langseth, 2002).

However if we analyse literature, we can see that literature concerning theoretical models and the mobile learning scenario has only recently started to appear.

The fundamental question is—which learning theories can be applied to mobile learning, and which educational activities can be followed using mobile devices? A complete and detailed analysis of mobile learning experiences making use of existing pedagogic theories is published in the report by the Nesta Futurlab titled *Literature Review in Mobile Technologies and Learning* (Naismith, Lonsdale, Vavoula, & Sharples, 2005). The report concludes that at present there is no theory about mobile learning; we must work towards an approach that can integrate and put together elements of various theories, those elements that are most likely to support the various learning activities.

In fact, the authors emphasize that mobile devices can support a wide range of activities for students of all ages and that the most significant experiences involve an eclectic approach, where many theories are harmonically mixed. Sharples, Taylor, and Vavoula (2005) stress that learning is a social process which occurs within a context where students cooperate with each other and with their teachers, in order to arrive at interpretations of the real world. Learning occurs when technology is used through the continuous exploration of the external world and the negotiation of its various meanings.

OUR BLENDED MOBILE LEARNING EXPERIENCE

In the spring of 2006 the Nomadis lab of the University of Milano-Bicocca designed a blended mobile learning training course, which included two face-to-face meetings and a learning unit to be used on the Pocket PC. It was decided to use the blended learning methodologies since it is believed that both e-learning and m-learning present a series of pros and cons, as in all new applications. Therefore, the forms of blended learning are able to take advantage of the benefits of the technological innovation without having to sacrifice the strong points of the more traditional and consolidated modalities of in class learning.

One of the main reasons why the Nomadis lab has started this experience is the wide spread use of mobile devices, their portability and their cost that has now become accessible for most people. The success of these mobile devices is also connected to their operational flexibility and wide use for non-didactic purposes (Corlett, Sharples, Bull, & Chan, 2005). A handheld computer easily becomes a multimedia display unit for listening to music, for watching videos and images, as well as having mobile telephone functions. As many experiences testify, learning through mobile devices can also be fun for users (Facer, Joiner, Stanton, Reid, Hull, & Kirk, 2004; Göth, 2003; Prensky, 2001; Savill-Smith & Kent, 2003; Schwabe & Göth, 2005; Seppälä, 2002; Seppälä & Alamäki, 2003).

Another critical element which has been observed and that can enhance the success of mobile learning has underlined that with this kind of remote training the learning phase is not linked to a special space any longer, but it becomes a potentially omnipresent source of learning.

As stressed by Graham (1997), Steinberger (2002) and Figg and Burston (2002), with regard to its user-friendliness, the instruction manual is not usually necessary in order to learn how to use a mobile device. In less than 30 minutes, a new user is able to become familiar with its main functions and its software so that he can follow a course autonomously (Prensky, 2004), since most users are already used to similar devices in everyday life, for example, mobile telephones. However, this cannot be a valid assumption for personal computers, since the lack of familiarity with operational environments means that training sessions of a minimum of one day are needed by users who are not familiar with computers, plus one or more days to practice with the application environment (Attewell & Savil-Smith, 2002).

The Structure of the Experience

This experience included three steps:

1. A face to face meeting with the participants, where the Pocket PC was introduced and distributed to them after the administration of a pre-questionnaire;
2. Supply of the learning unit;
3. A face-to-face meeting with the participants in order to share their comments and to distribute a questionnaire to assess their experience.

The Sample

Our sample is composed of 16 doctoral students between 28 and 33 years of age. The recruited students participate in a programme of doctoral studies on "Technologies for Communication and Information Applied to the Knowledge Society and to Educational Processes" organized by the University of Milan Bicocca. The doctoral students come from various university departments such as Sociology, Philosophy, Education, Communication Sciences and Psychology.

The Model and Didactic Strategies

The transformations in the current didactics used for mobile learning are mainly linked to the fact that the learning activity takes place through a new tool—the mobile device. And, just as on line teaching differs from face to face teaching, teaching via mobile devices must also take into consideration various elements which differ from face to face and on line didactics.

Obviously, these elements are not exclusively linked to the mobile device in itself, but to the peculiarities of mobile learning. Just as on line teaching cannot be a simple transposition of personal teaching in the most traditional sense, the same is also true for teaching via mobile learning—it cannot be a mere transposition of on line didactics.

From tests and studies carried out so far, it seems that the technologies are very flexible they can support various models, from those based on the transmission of contents to those based on interaction, experience and the building up of knowledge.

Starting with these considerations, in each mobile learning object we decided to let the transmission of contents be followed by a topic for reflection or by homework, the results of which were shared during the next face-to-face meeting.

To create this learning unit, the guidelines of Steinberger (2002) and Figg and Burston (2002) have been taken into consideration. According to them (as quoted by Trifonova & Ronchetti, 2003), "Modules should be short, and last no longer that 5-10 minutes. Users should be able to use their small fragments of time spent waiting or idle time for learning, reading small pieces of data, doing quizzes or using forums or chats. It is important that it is simple, fun and with added value functionality. The computational power and other properties of mobile devices make it difficult in most cases to use complex and multimedia content, although devices of the same size are used for entertainment with great commercial success. It should be possible to use an m-learning system without reading a user manual, and the experience of studying with the help of such devices should be interesting and engaging."

The Pre-Questionnaire

The pre-questionnaire was created by selecting thematic areas from a survey made on scientific literature regarding mobile devices in general, and mobile learning in particular. It is divided into four parts.

In the first part, several free associations are requested (max 5) for four concepts – stimuli: mobile telephones, desktop, notebook and handheld computer. In the second part, participants are asked to give their opinion about the associations they gave: positive (+), neutral (0) or negative (-) ratings.

In the third part, they had to answer several questions about their own mobile devices and their use.

In the last part, various social-personal questions were asked, such as sex, age, residence, education, profession, average time to reach their place of work and the use of Internet.

The goal of this questionnaire is to understand how the learning instrument can be used, something which was not done in the blended e-learning experience. For this it is necessary to understand what mobile devices our subjects have, how they use them and how they are willing to use them.

The Learning Unit

The theme of this learning unit, in text format (*.ppt), video and audio, is mobile learning and it includes four learning objects ("Some Definitions", "The social-cultural Context", "The Features of M-learning" and "What can be done with a Mobile Device"), which last approximately ten minutes each.

Every mobile learning object has a contents part followed by a few reflections to be made or a task to complete. The results of the reflections and the tasks were shared during the final face to face meeting by the participants, and this led to the co-construction of common knowledge.

The Assessment Questionnaire

The areas to be investigated in the assessment of the quality of the mobile learning experimentation have been identified also in the literature about mobile learning. In particular, we have considered:

- The features of fruition typical of mobile learning, such as the chance to access the training contents anywhere and anytime;
- The features of the mobile device in itself, in this case the Pocket PC both in terms of hardware and software;
- The ways the user feels the mobile device is a learning tool;
- The structuring of the course both in terms of content organization and the stimuli and homework assignments proposed.

For example, regarding the features of the mobile devices in themselves, if subjects have never used a PDA before, they are asked if they had any problem using the Pocket PC. They are also asked to assess the following aspects using a 5-point Likert scale:

- Readability of the contents on the screen
- Use of the pen
- Surf/change between menus
- Screen colours
- Battery life
- Audio

As for the fruition features, the spaces and time gaps during which the mobile device has been used to benefit from the learning unit have been investigated. It has also been asked if using the Pocket PC in public has been easy and accessible, or if it has been difficult.

If some difficulty was experienced, the student had to specify if it was caused by lack of concentration, reception, and reading of the screen or by other factors.

Regarding the course contents and organization, after a question about a general assessment of the course, the students are asked to assess the proposed topic and its relationship with their training path using another 5-point Likert scale. The students are asked to assess the stimuli and the homework assignments proposed at the end of each single mobile learning object, and they also have a final meeting with the trainer.

Finally, they had to indicate three positive and three negative points of the module and also the main problems they had, making suggestions regarding the development of the module offered to them.

Conclusions of Our Experience

From the realization of this short-term, small-scale project we have learned that blended mobile learning can actually play a key role in the training path for focused purposes. In particular, we have seen that mobile learning permits potentially omnipresent learning. Generally speaking and practically at any time from waiting at the bus stop to an underground ride, time which would otherwise be considered "wasted" or time in which it was previously not possible to enrich with learning contents becomes a potential learning moment, all thanks to mobile learning.

From the assessment questionnaire and the final meeting, we noticed that participants enjoyed learning via Pocket PC, and they found that the proposed stimulus was interesting at the end of each mobile learning object. Even if our subjects came from nontechnical university faculties, they did not experience particular problems in using the mobile device.

FUTURE TRENDS

Regarding future trends, first of all it is extremely interesting to see which innovations will take place, both on the software and on the hardware level. Secondly, it is important to understand what the real application fields of this new learning methodology will be. According to Prensky (2004), through a mobile device it is possible to learn almost anything and in fact, mobile learning has been used at the most diverse levels from the year 2000 to date. However, there are still many sectors where mobile learning has not been used. For example, the Nomadis lab has on ongoing blended mobile learning experimentation in an Italian scientific technological park. This experimentation uses mobile learning for the training of managers of technological transfer. And last, but not least (last but definitely not less important) an important step consists in the development of a theory for mobile learning, which as we have seen does not exist yet.

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KEY TERMS

Mobile Device: Mobile technologies such as Pocket PC, PDA (personal digital assistant), Table PC, eBook, mobile phones, and other portable devices.

Mobile Learning: Modality of the distribution of almost any educational content, for example: entire traditional courses or new mini-courses, using mobile device.

Modeling Business Actions

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INTRODUCTION

The effective use of information and communication technology, or ICT (Barua, Kriebel, & Mukhopadhyay, 1995; Burn & Szeto, 2000; Mahmood & Mann, 2005; Mukhopadhyay, Kekre, & Kalathur, 1995; Sircar, Turnbow, & Bordoloi, 2000; Zammuto, 1982), requires a careful design of information systems and the business processes they support from a communicative perspective (language-action perspective). The literature on language action provides a broad spectrum of frameworks for modeling business processes, for example, business action theory (BAT; Goldkuhl, 1996, 1998; Goldkuhl & Lind, 2004), dynamic essential modeling of organizations (DEMO; Dietz, 1999; Dietz & Habing, 2004; Liu, Sun, Barjis, & Dietz, 2003; van Reijswoud, 1996; van Reijswoud & Dietz, 1999), action workflow (Denning & Medina-Mora, 1995; Kethers & Schoop, 2000; Medina-Mora, Winograd, Flores, & Flores, 1992), action-based modeling (Lehtinen & Lyytinen, 1986), and conversation for action (Winograd & Flores, 1986). Among these frameworks, BAT can be seen as the most general because it does not commit the modeler to any specific methodology allowing for a free choice of the most appropriate one in the context. A possible choice would be that of the situation-adaptable work and information systems modeling method (SIMM; Goldkuhl, 1996).

But the lack of a dedicated methodology also is a disadvantage because it forces the modeler to use one that was not tailored for BAT and hence does not support the application of BAT. The methodology might lack essential BAT concepts or it might even be partially in conflict with BAT. These issues have been explored in several papers comparing BAT with DEMO (van Reijswoud & Lind, 1998; Verharen, 1997) and action workflow (Goldkuhl, 1996; Verharen, 1997). It can therefore be argued that the introduction of a BAT methodology is worthwhile. A first step in that direction is explored here by developing a rich set of concepts for a business modeling language that is inspired by BAT.

The following sections are structured as follows: We first introduce the BAT framework and the generic layered patterns for business modeling. In the section "Refining the Framework," we combine phases and layers into one coherent framework and suggest a possible classification of business acts based on a material and speech-act analysis of the basic activities of BAT. We proceed by specifying the notational elements of a potential language; we finally present an application of such a language for the purpose of commitment analysis.

BACKGROUND: BUSINESS ACTION THEORY

Business action theory has been introduced by Goldkuhl (1996) and was refined and adapted on the basis of further empirical evidence in Goldkuhl (1998) and Goldkuhl and Lind (2004). It is based on socio-instrumental pragmatism (SIP; Goldkuhl, 2002) that combines communicative (social) and material (instrumental) aspects of actions. The roots of BAT are speech act theory (Austin, 1962; Searle, 1969) and the theory of communicative action (Habermas, 1984).

According to BAT, business interaction involves two principal players, the supplier and the customer, where the former sells to the latter. At the core of BAT is the so-called business transaction that consists of six phases. Table 1 shows these phases and the generic business actions that constitute the phases on the respective side of the transaction (i.e., supplier or customer).

Orthogonal to the phases BAT offers another dimension, layers, that was introduced in Lind and Goldkuhl (2001). They extend and modify the layers originally suggested by Weigand and van den Heuvel (1998). Layers refer to the granularity of an action and in BAT they are, from fine grain to coarse grain: business act, action pair, exchange, business transaction, and transaction group.

M

Table 1. Generic business actions

Phase	Supplier	Customer
Prerequisites phase	Product/offer development	Identification of problems/needs
Exposure and contact search phase	Offer exposure	Contact search
Proposal phase	Offer	Inquiry
Commitment phase	Order confirmation	Order
Fulfillment phase	Delivery, Invoice, Receipt of payment	Receipt of delivery, Payment
Assessment phase	Acceptance, Claim	Acceptance, Claim

REFINING THE FRAMEWORK

To develop elements of a business action language, the BAT framework is refined as shown in Figure 1. The transaction layer is divided into the exchanges (or phases) that have already been mentioned. An exchange consists of two hand-over actions: One is directed from the supplier to the customer and the other vice versa. These hand-overs usually happen one after the other where the second happens in return for the first, but the order is not predefined; that is, in some cases, the supplier hands over first and in others the customer hands over first.

An action pair consists of two business acts, an initiative and a response. They have already been introduced as trigger and response in Lind and Goldkuhl (2001). On the lowest layer, a business act consists of one or more functions. The importance of these functions was already recognized in Goldkuhl (1996) where they were named mixed communicative actions. If we apply a so-called material and speech act analysis to the remaining generic business actions, we get the results shown in Table 2.

These results show that a busines act typically has one or two functions. The communicative function is always present but there might also be another function of either type (see also Figure 1). We are aware of the fact that such a list of generic actions cannot be a prescriptive template for all business interactions, but it shows how material and speech act analysis can identify material and communicative functions. The results of this analysis can help us in finding a set of recurring functions that can be used as a pattern for a modeling language for the analyzed domain. If we compile the identified material and communicative functions and sort them according to the illocutionary

Figure 1. Structure of the layers

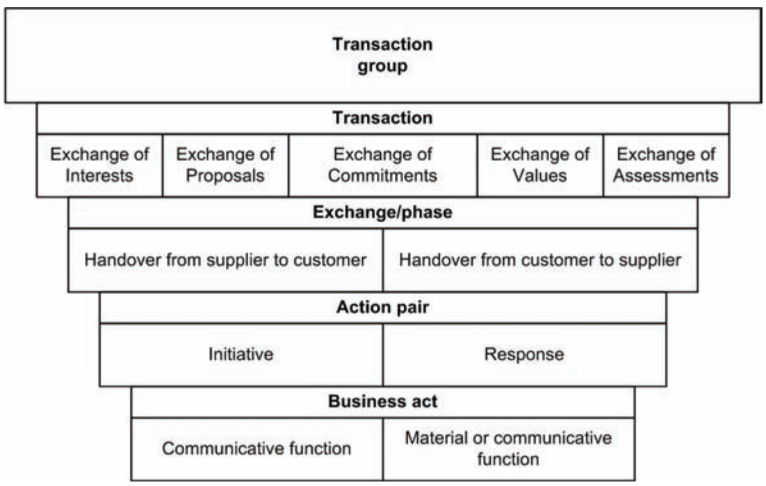


Table 2. Material and communicative functions of the generic business actions

Business Action	Material and/or communicative function
Offer exposure	*State* general offer
Contact search	*Express* interest
Inquiry	*Request* commercial offer + *Express* interest
Commercial offer	*Offer* delivery + *Request* order
Order	*Request* delivery + *Offer* payment
Order confirmation	*Promise* delivery
Delivery	*Transfer* merchandise/*Perform* service + *State* delivery
Invoice	*Request* payment + *State* contract fulfillment [supplier]
Receipt of delivery	*Accept* delivery + (*Accept* contract fulfillment [supplier])
Payment	*Transfer* money + *State* contract fulfillment [customer]
Receipt of payment	*Accept* payment + (*Accept* contract fulfillment [customer])
Acceptance	*Accept* contract fulfillment [supplier or customer]
Claim	*Request* contract fulfillment [supplier or customer]

points introduced in Searle (1979), adding a column for material functions, we arrive at the structure shown in Table 3. This classification can be seen as an extension of van Reijswoud, Mulder, and Dietz (1999).

Based on the suggested refinements, the next section develops a set of elements that describe the outline of a potential modeling language for BAT.

LANGUAGE ELEMENTS

As mentioned earlier, there are already methodologies implementing language action concepts. We therefore propose a set of elements that can be used to enrich them. The techniques for that are offered by (situational) method engineering (Ralyté, Deneckère, & Rolland, 2003). They are extending an existing method, creating a new one from chunks of existing methods, and constructing a new method from scratch. Using the first approach, method extension, we might for example enrich and refine the language of SIMM with the elements introduced here.

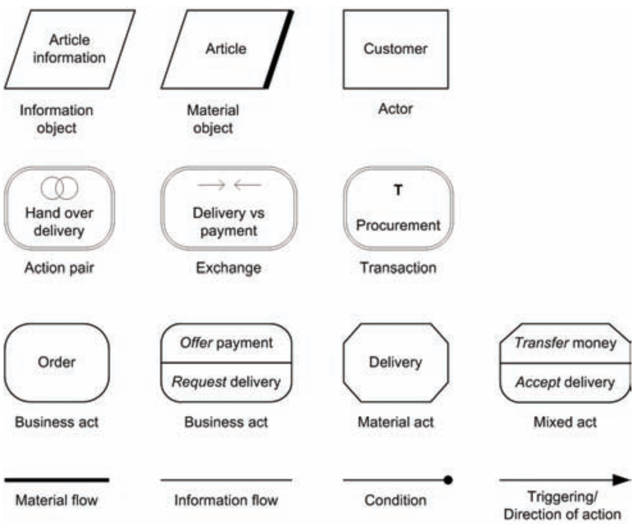
We propose that a business action language requires at least three element categories: actors, actions, and (action) objects. We define objects according to SIMM where many object types are introduced. Two of them, information and material objects, are shown in Figure 2. Actors are denoted by a rectangle with the name of the actor. The actions are divided into business acts (layer 1) and complex actions (remaining layers). Complex actions are represented by a rounded rectangle with a double line. A symbol can be used to identify the layer: two intersecting circles for an action pair, two arrows pointing towards each other for an exchange, a "T" for a transaction, and a "G" for a transaction group. For business acts, we also use the rounded rectangle and the octagon for material acts. Both shapes have only one line to show that the act is elementary. The shape can either contain the name of the business act or the respective function(s) where the illocution is italicized. For multiple functions, the shape is divided into horizontal compartments, one for each function. If material and communicative functions are mixed, we also mix the respective shapes. Figure 2 shows an overview of the notational elements for a business action language.

Undirected arcs represent material flow (thick arc) or information flow (thin arc). A condition arc shows that one action is a condition for another. The end with the black dot is attached to the latter. The arrow serves two purposes. If it points from one action to another, the former triggers the latter. If it points from one actor to another, it represents an action that is directed from the first actor to the second. In this case, the name of the action is written along the arrow. It can be accompanied by a symbol denoting the layer. For complex actions, we use a diamond for business

Table 3. Classification of material and communicative functions

<table>
<tr><th rowspan="2">Material</th><th colspan="5">Communicative</th></tr>
<tr><th>Expressives</th><th>Declaratives</th><th>Assertives</th><th>Commissives</th><th>Directives</th></tr>
<tr><td>Transfer (moving an object)</td><td rowspan="3">Express</td><td rowspan="3">Accept</td><td>State</td><td>Promise</td><td>Request</td></tr>
<tr><td>Apply (using an object)</td><td rowspan="2">Reply</td><td rowspan="2">Offer</td><td rowspan="2">Ask</td></tr>
<tr><td>Transform (changing an object)</td></tr>
<tr><td colspan="6">Perform</td></tr>
</table>

Figure 2. Notational elements for a business action language



acts with a material function and a circle for business acts without a material function. As an alternative to annotating the arrow, the respective action shape can be combined with the arrow. In the next section, we use the language elements to define two diagram types that are suitable for analyzing commitments and to help with detecting bad commitment management.

COMMITMENT ANALYSIS

Commitment analysis in terms of language action was introduced by Auramäki, Lehtinen, and Lyytinen (1988). Our work has been carried out in the context of a project that involved two companies that have a very close business relationship. One of them is a retail chain in the home textiles and decoration industry, the other a third-party logistics provider (LogPro) that performs all inbound and outbound logistics for the retailer. Our goal was to discover problems in their relationship and to suggest solutions by analyzing order processing and delivery. We used SIMM's interaction diagram first but discovered a need for information on action type and level so we enriched it with the features introduced above. The resulting diagram is shown in Figure 3.

The process starts when Headquarters (of the retailer) send an estimate of the capacity for handling orders in advance. A customer order is initiated by the Shop on behalf of a customer who wishes to buy an article that is not available in the Shop. A refill order is triggered

Figure 3. Enriched interaction diagram

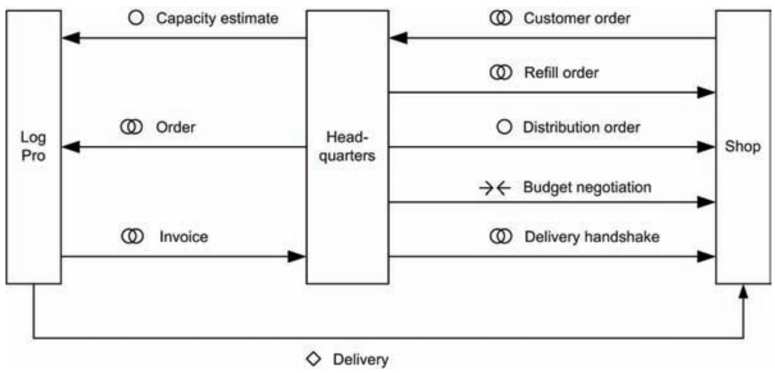
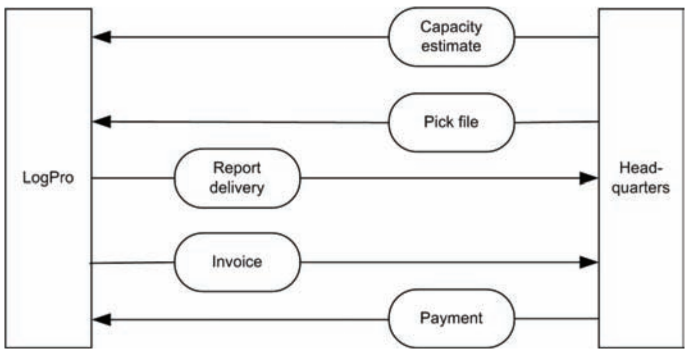


Figure 4. Detailed interaction diagram

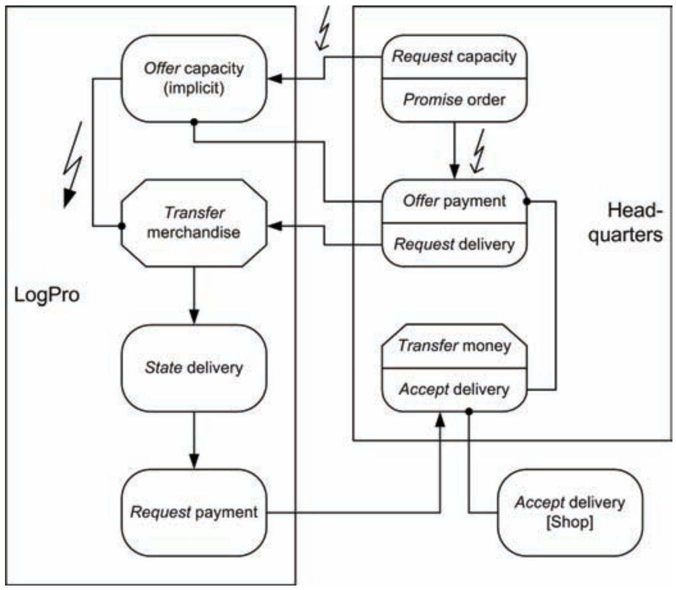


by Headquarters whenever the Shop's stock is running low on articles of the basic assortment. Both actions are on the action-pair level because they require some kind of confirmation from the partner. A distribution order is based on the budget that was negotiated before, and the Shop has to accept it as part of their franchise obligations. It is therefore a single speech act with informative character. Budget negotiation is a bilateral process initiated by Headquarters that consists of an exchange of budget proposals. Orders of all types are combined into one by Headquarters and forwarded to LogPro who perform delivery to the Shop. Headquarters inform the Shop about the upcoming delivery and receive a confirmation that has arrived (delivery handshake). In regular intervals, LogPro bill their services to Headquarters.

On the basis of this overview, we developed detailed interaction diagrams. The one between LogPro and Headquarters is shown in Figure 4 on the business-act level. Headquarters send a capacity estimate first. On the day of delivery, a pick file is transferred to LogPro that contains the order data. This is used by LogPro to pick the appropriate articles from the shelves and to pack them for delivery. As soon as the articles are on their way, LogPro reports the delivery to Headquarters. At the next billing occasion, LogPro send an invoice and Headquarters make the respective payment.

For performing a commitment analysis, we need more detailed information about how actions are related to each other. For that, we have to exhibit the functions of the actions because they lead to the establishment and fulfillment of commitments. When they have been made explicit, we can show the conditional and causal relationships between the functions. This in turn helps us to uncover broken commitments. For this, we need a new type of diagram, the action function diagram (see Figure 5).

Figure 5. Business act diagram



Each actor box covers the actions that are performed by this actor. The capacity estimate is an action that implies both a request to provide this capacity and a promise to place an order that requires approximately the requested capacity. LogPro makes an offer to provide this capacity subject to Headquarters' order in general and their offer of payment in particular. This offer is implicit (i.e., not communicated) because LogPro is required to provide the respective capacity by the terms of the frame contract. The provision of the capacity is a condition for the ability to perform the delivery that is triggered by the respective request from Headquarters that is a function of the order. The other function, offer payment, is subject to an accepted delivery. The performed delivery triggers a respective report (state delivery) which in turn triggers the invoice (request payment). The latter triggers the payment (transfer money) but only if the Shop has confirmed the arrival of the delivery. Headquarters does not explicitly accept the delivery towards LogPro but does so implicitly by paying the invoice. Therefore, "transfer money" and "accept delivery" are functions of the same business act.

The business act diagram has clearly shown us that the commitment concerning the capacity is broken in three different places (see the flash symbols in Figure 5):

1. Headquarters promise that the order will require the capacity that was requested, but in reality, the orders often deviate substantially from the estimates.
2. The request for the capacity is not in a LogPro-suitable format so that they can hardly plan for providing this capacity, but Headquarters assume that the capacity is provided.
3. As a consequence of 1 and 2, the conditions for performing the delivery are not given in many cases. This leads to higher costs and sometimes failure to meet the deadlines for delivery.

We have used this approach for other parts of the business process where we also succeeded in finding mistakes in commitment management. Among the problems we have identified are indistinct communication structures, lack of trust, lack of information, excessive communication, and high transaction costs.

CONCLUSION

Business action theory is a stable framework for analyzing business processes. It can guide the modeler in finding appropriate abstractions of the studied process and in relating different parts of the model to each other.

These features are achieved by rooting the theory solidly in an ontology, that is, socio-instrumental pragmatism, that describes all important aspects of social behavior in general and business behavior in particular. Another cornerstone of BAT is the existence of different dimensions, layers, and phases, and the multifunctionality of business acts. All these features contribute to better business process models. But the support of the modeler can be strengthened by providing a modeling language that reflects these features of BAT. We have suggested a number of elements of such a language, and we have shown two ways in which they can be used: to extend existing modeling methods (e.g., SIMM) and to define new diagram types that are adapted to a particular modeling situation.

As an example for such a situation, we have used the analysis of commitments that are created and fulfilled (or broken) in the course of a business process. An enriched interaction diagram and an action function diagram, two examples of newly defined diagram types, have proved useful in this context, but the language elements are only a first step towards a language. The further development of such a language depends on whether they can also be used in other contexts. This is subject to future research.

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KEY TERMS

Business Action: A social action aimed at an actor with the purpose of achieving a goal.

Business Act: A business action that cannot be decomposed.

Communicative Function: A language-based function of a business act that aims at changing the state of mind of the addressee. It is used for coordinating business activities.

Function: An aspect of a business act.

Layer: Granularity of a business action such as business act, action pair, or exchange.

Material Function: A function of a business act that changes the state of the physical world.

Phase: A stage in a business process such as proposal, fulfillment, or assessment.

Modeling Wireless Local Area Networking in Higher Education Institutes

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INTRODUCTION

In recent decades, local area network (LAN) has taken a dominating role as communication media inside organisations between individual users and the services they would like to use. The personal computer (PC) has become a basic piece of furniture in every workplace like a chair and a desk. The communication media has evolved from a thick clumsy coaxial cable to flexible thin pair cable or even thinner very high capacity optical cable. In other tools, the development has not been stopped either, but instead computing tools, equipment, software, and communication applications have seen further development with increasing speed. The computers have been packed to very compact form, and they move around with people everywhere, and the network is following them in wireless form. Fast moving, modern people are choosing their own time and place to work.

The radical change does not concern only enterprises, but various organisations, particularly educational institutes, are changing. Computerisation and the increase of networking have been very fast. Wireless LANs are one of the latest examples on this; many institutes are forerunners in taking new network innovation into use. New methods of teaching and learning and better ways of student working are matters of interest in many scientific communities and schools.

This article is partly based on the research being done by Turku University of Applied Sciences in Turku, Finland. The research was started in spring 2006 and is backed by the Ministry of Education in Finland. The aim of the research is to do the basic information collation of the current implementations and the use of wireless local area networking in Finnish universities of applied sciences (former polytechnics). Based on certain models and best practices for WLAN (wireless local area networking), networking is created.

BACKGROUND

The tendency towards networking has been started at the same time at schools, rather than in other kinds of organisations in society. The school system as a whole is multiform because the lowest level of education is very different from the highest educational and scientific institutes. Also the information technology and networking needs, use, and resources vary. How equipped a school organisation is with information technology tools is very dependent on the resources of the bearer organisation. The owner of an institute can be a public company, city, or state organisation. In the past, institutes of higher education with IT programs and scientific research organisations got the very first central computers around which the computer centres were built. Nearby these centres, the first computer classes were established where the students could get access to the computers either by queuing their turn in computer terminal rooms or by reserving their time slots beforehand to few computer terminals.

In the course of time, the central computer capacity was squeezed into even smaller space giving birth to mini- and microcomputers and at last the widespread computer capacity was connected together with networks. Modern local area networking was created. Today, much of the information handling intelligence and capacity lays on the client desktop PCs. Different services, applications, communication, and other facilities are fetched from different servers behind the network. The physical structure of the modern local area network is mostly based on fixed cables that reach out to all relevant rooms and workplaces. The computers are plugged to wall panels with a data cable and not at all easily moved around.

At schools, the computer based learning happens in computer classrooms. Entire rooms have been furnished with computers, cables, computer tables, and special air conditioning to fit for computer based working. The students have scheduled times for working in these classrooms based on their specialisation, group, or class. Some students do also have a computer at home, but still most often the devices are firmly plugged to the wall.

As the information needs have grown and the technology has improved, the ways to access and handle information have also changed. One of the biggest changes has been the way to transmit voice communication between people. Earlier, there was the fixed network to carry the speech, but then the telephone cut the wires and started the time of personal communication by jumping into each individuals' pocket. People could move about based on their instant needs and perform work tasks or leisure activities in different places as they wish.

Computers have started to demand the same grade of freedom as telephones. Two things have happened by the help of electrical circuit and component development. The computer processors have penetrated the telephones and personal computers have turned to very small laptop computers that can easily be carried with a person. The communication line is converting into wireless and the era of wireless local area networking has started.

THE TECHNOLOGY OF THE WIRELINE AND WIRELESS NETWORK

A modern data network in an organisation consists of wired (fixed) and wireless IP-network. IP stands for Internet protocol and refers to transmission of data packets according to certain way defined in the communication protocol specification. WLAN network uses wireless communication between the base station and the end user station. The main components of the wireless communication are the wireless adapter inside the user device and the base station. Both have transceiver-receiver hardware and certain software installed. In addition, there are antennas, power equipment and possibly some routing, switching, data security, and printing services available in the base station.

In the course of time, many new standards to refine WLAN were accomplished and the possibilities of using the WLAN have been made better. In the beginning, the speed and other features of wireless communication were minimal. After the first standard called IEEE 802.11b, new standards were published soon and the communication features were substantially increased. For example, the speed was increased from 11 Mbps (millions bits per second) to 54 Mbps.

One of the most important things in WLAN is the radio technique used. The use of radio frequencies is strictly regulated as whole and actually the frequency space is divided into regulated and unregulated frequency band. The WLAN typically uses the latter and thus the organisation or an individual person implementing WLAN need not to apply for license from the authorities. The unregulated frequency band is typically in the 2.4 or 5 GHz area. Furthermore, radio waves as communication media do have qualities and characteristics that have to be carefully taken into account like reflections, absorption, attenuation, and radiation. One of the future challenges is also how to overcome the constant lack of radio frequencies for communication purposes as wireless communication volumes grow.

The construction of WLAN network demands careful planning and considerable amount of work. With measurement equipment, the location for each base station is defined to ensure the coverage without gaps to desired areas. The coverage area of each base station is spherical although the borderline is not unbroken. Because of this, the coverage of neighbouring base stations has to overlap somewhat to the next station to avoid breaking down the communication signal while moving from one coverage area to another. The recommendation is usually to have approximately 30% of overlap in signals from base stations next to each other. The signal is degraded fast while moving away from the base station and walls, and other constructions can quicken the degradation and even kill the signal completely.

The capacity of the network is strongly dependent on the amount of users within reach of the base station, because the total capacity is divided between the users based on competitive reservation of resources. Additionally, the use of different radio channels on the frequency area is important. The unregulated 2.4 GHz frequency area is divided into 13 different channels, and they are overlapping somewhat to each other. Actually, only 3-4 clear channels can be used in the same area at the same time. It is thus recommended that either a proper channel usage plan is made or automatic channel selection feature is set on in the base stations.

The most severe concern in WLAN is related to data security. The most important definition of policy is whether the network is open or closed security-wise.

In an open network, the user is not required to authenticate at all and thus the identification of individual user is impossible or at least very difficult. In fully closed networks, all users as persons need to authenticate with their given IDs and passwords or with a visitor identity to the network and even the computer is identified based on hard-wired codes. In between these extremes, there are several networking models that can be used.

Another important choice is which user groups are defined in an organisation and which services are allowed for each of them. In many cases, the network is divided into inner and outer network. In the inner part of the network, there are the critical services that need to be protected carefully against any misuse. The outer network is for common services like Web services. The question how to mix and match the user groups and services is answered best by a proper security policy. In all organisations, it is very important to define the security policy in which at least physical security, user authentication, device configuration, set up requirements, services offered, software upgrade rules and methods, network management, documentation, and encryption are determined. The coupling methods and tools of fixed and wireless networks need to be defined as well.

WLAN: NETWORKING IN FINNISH UNIVERSITIES OF APPLIED SCIENCES

This article is partly based on the research being done in University of Applied Sciences in Turku, Finland. The research was started in spring 2006 and is backed by the Ministry of Education in Finland. The aim of the research is to do the basic collation of the use of wireless local area networking in Finnish universities of applied sciences (former polytechnics) and to draw some conclusions on the best practises and network models to be recommended for an educational institute. The main method of the research has been the interviews and questioning and two rounds of information collation were done. The following steps included the analysis of information, drawing conclusions, and setting up some test networks based on the results. The Universities of Applied Sciences form an important part of the Finnish higher education institution network and supplement the offering of other universities by offering the highest grade in vocational education.

At first, there was altogether 25 colleges interviewed out of 30 during spring 2006. The main focus was in clarifying the current WLAN situation at schools with the best specialists. On the second round, 23 IT managers out of 30 took positions on some matter of opinion questions.

In the analysis, it could be seen that in about 75% of the institutes, the building of WLAN was already started. The rest of the institutes had no or less than five base stations. Early comers had started the building process 3-4 years ago. The average cover of the WLAN varies, but roughly, it is around 20% of the total surface of the schools. There was no reliable statistics available in most of the schools about the current user amount and simultaneous users. During the rest of the year, the amount of base stations is expected to increase from the current number of 800 to over 1100 base stations in these institutes.

As the IT managers' opinions were asked, they stated that they clearly see that WLAN could be a strategic advantage for their institutes. The personnel are believed to retool their computers to laptops in a couple of years; in some opinions, the transition might take 3-4 years. The students are increasingly buying their own laptops, and this is probably going to decrease the amount of fixed computers and computer classes at schools. The transition can be believed to be fastened through the wider coverage of the WLANs and with lower prices of laptop PCs.

The history in WLAN implementations seems to be varying. In many cases, the first implementations were done by individual persons who just wanted to move around in their own workroom with their computer. Some other persons followed these early adapters and possibly added some nearby base stations to the same network segment, giving birth to the first department or faculty WLANs. In some cases, these wild implementations were not at all known by the central IT management at school.

Afterwards, more organised projects have been evoked, and the central management has taken their role in WLAN networking, too. Many implementation projects nowadays are started with careful planning. Plans are made concerning the desired network policy, coverage, and financing. After this, the careful technical measuring of the premises is done. While doing this also, the rest of the wild networks are found and usually either smelted to the new network plan or simply torn down. In some projects also, student workforce is used to make the measurements and implementations although this is not always preferred. Most people in the organisations rely on their own specialists, but in some cases network planning and implementation is outsourced and only the maintenance and network management is left to organise.

Usually, it is very well known in the institutes that WLAN-capacity is very much dependent on the amount of simultaneous users in each network spot. Also, it is known that roaming is dependent on the continuity of the coverage from one base station to another. The growing demand for wireless network capacity is also well known and accepted. Despite of these things, a proper planning scheme is not always seen to happen. This could be a critical factor for the future success of WLAN-networking and could cause higher costs while fixing the networks in the end.

WLAN: Network Models

Hot potato in WLAN is whether to use open or closed access networks. This problem is mainly dependent on the questions of whether the school's network is only inside the school premises or if there is also an outside coverage reaching out to a complete campus or city network area, where the institute is a part of the totality. If and when the school is alone and is just building a network access inside its premises, it is really up to the school itself to decide whether to have open or closed access and to whom to offer it and with what services. The question becomes much trickier if the school is not living alone. Also, attempts to create European or worldwide educational roaming visitor communities create some challenges in construction of networks. In this research, it was found that there are many different common network types used at the moment:

Premises and Campuses:

- WLANs that use open access with no authentication and meant mainly for students and visitors with minor accessible services.
- WLANs with user authentication by the official institute user IDs or local visitor IDs. WWW-based authentication is used and either there is encryption involved or not.
- WLANs that have closed access and meant only for the personnel with the official institute user IDs. Also, the accessing workstation is identified by some certification method.

City Networks:

- WLANs open to everybody around the city with no authentication.
- WLANs with authentication by official IDs either from a participating institute or, for example, a commercial party like ISP (Internet service provider).
- Fully commercial networks with authentication and charging by the ISPs.

In open networks, it seems to be a major question whether there are potential risks in having the door open for potential network intrusion into inner networks via the WLAN or for other misuse. In Finland, some concern has been shown by the Finnish Communications Regulatory Authority (FICORA) about instances offering open services. One consideration is whether such parties should need to write a telecommunication notification to Ficora before starting operations or not. And another consideration is of course who assumes the responsibilities of a network operator concerning data security, consumer rights, and information giving to authorities in case of misuse.

Encryption of the communication and the authentication methods varies in different institutes. The most simple methods are easily breakable and do not provide very high security against misuse. The most advanced methods on the other hand do base themselves in new standards like 802.1X, Radius (Remote Access Dial In/Out Service), VPN (Virtual Private Network), and VLANs (Virtual LANs) and do require substantial amounts of hardware and software to support them and also quite a lot of expertise in implementation and maintenance. These methods make it possible to build secure enough WLANs that can be attached to the fixed network and pave a relative secure way to proceed towards the future wireless networking.

As typically the Finnish universities of applied sciences would not like to assume the role of a common teleoperator, there are some specific categories of technical networking that can be recommended for implementation:

- **Open model:** No authentication, coverage strictly inside premises, security warnings provided if no encryption available, minimum set of services, for own users only.
- **Open model with authentication and interconnection:** Coverage in campuses shared with

other institutes, security warnings provided if no encryption available and minimum set of services, for secure connections VPN or other security protocols are used, access granted for users from all participating institutes or authorised visitors through the same infrastructure.
- **Closed access model:** Access for institute and authorised visitor users only. Technically 802.1x, meaning authentication is used together with encryption and some security access protocol like Radius.
- **Strictly closed access model:** Access for identified institute users and hardware only. Technically 802.1x, meaning authentication is used together with user and hardware certification methods.

Fortunately, if not a single network model is responding to the total need of a particular organisation alone, the most modern technology allows us to implement several models to the same network infrastructure and interface at the same time. In such a solution, different networks sit on top of each other, and the users are able to pick up the right network for their needs. This multipurpose network model is an ultimate in networking as it gives a freedom of choice for users and organisations. On the other hand, WLAN networking will turn into investment business through the cost and effort of implementations and the old days of free and wild networking are left behind.

CONCLUSION

The computers and the networks have developed very much in the last few years. The move over to laptop computers from fixed terminals and to wireless networking from wired work spots seem to be inevitable. People are very much aware of the benefits of being able to move around freely while still being able to communicate in work and in leisure, which is enabled by the new generation laptops, handheld telephones, and portable devices. The technology as such is complicated and has many details in it to be further developed and solved before all the facilities are in place.

The direction of the development seems to be clear according to at least the IT-managers. The laptops are going to displace the traditional computers as personal tools and even the student work will be based on new kinds of arrangements. The main question still on the way is the data security in WLAN communication. As the communication and security protocols develop all the time, it is only a matter of a short time when proper solutions are available and the implementation skills are organised. At the same time, wireless networking is assuming a new role of being an investment oriented business. Even the authorities are confused with the new scheme of things in wireless networking and are through some discussions creating their views on these new matters.

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KEY TERMS

802.1X: An IEEE-standard that defines the authentication method for user and workstation identification. It is used to secure any kind of network communication that involves allowing authorized parties to access networked resources (e.g., servers, hosts).

Authentication: Authentication is the method and procedure to identify the users who try to get into the network. The authentication procedure can include physical and software based identification means and nowadays is strictly based on the protocols that define all details.

Encryption: Encryption is a method to hide the clear text of the user data from misuse. There are several methods of encoding the original text and nowadays the method of encrypting is dynamically changed all the time during the transmission.

Laptop Computing: Laptop computer is a small computer held in one's lap instead on a table. The computer is very compact and small in size and is equipped with all needed software and hardware inside.

Network Access: The network access is the way to connect the computer into the network. The network access can be wired or wireless referring to the physical form of the networking media.

Network Coverage: The network coverage is the exact area where the signal from the nearest base station can be received. The coverage area is dependant on many things like the transmission power of the base station, locations of the neighboring base stations, and the physical structure of the building or campus.

Wireless Local Area Networking: A wireless data network that is used to transmit data packets between network communications users locally without wired connections to or between the computers. Known commonly as WLAN.

Multimedia Integration in Active Online Learning Environments

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INTRODUCTION

The terms distance learning, online learning, and Web-based instruction have become buzzwords and catch phrases for the new phenomenon of learning. These terms used to describe an ever-changing environment represent approaches that focus on opening the access to education and training provision for adult learners, freeing the adult learners from the traditional constraints of time and place. Online learning is one of the most rapidly growing fields of education around the world, and its potential impact on all education delivery systems has been greatly emphasized through the development of Web-based information technologies, multimedia, communication technologies, and, more importantly, the Internet.

Online and Web-based courses within the distance education environment have become popular with both students and educational institutions as the new mediums to deliver educational programs. For universities and other educational programs, they are an excellent way to reach students in diverse and distant locations. Some may also be used to supplement school enrollments since students can conceivable be anywhere and take the courses. Given their popularity and increased use, it is imperative that administrators and instructors monitor students' perceptions of courses using these mediums for delivery. Hopefully, this type of feedback can help in modifying and improving the learning environment and education programs so that course can function as desired by all parties.

With these concepts in mind, the purpose of this chapter is to identify the factors that contribute to the understanding, capabilities, limitations, and applications of multimedia in online courses. The information presented in this chapter will lead to the development and implementation of innovative strategies to promote quality teaching and student learning via the online and medium with multimedia. In order to effectively develop a conducive online course environment for the learner, instructional designers, educators, trainers, and facilitators must pay particular attention to the design of instruction, the mode of delivery, and the multimedia technologies employed to disseminate course content and materials to students. With this understanding, then and only then can we begin to harness the power of online learning with multimedia.

BACKGROUND AND LITERATURE REVIEW

Online courses with multimedia have the potential to generate new patterns of teaching and learning for students. This idea is strongly linked with developments in information and communication technologies; it is also close to the development of new learning needs and new patterns of information access and application and learning. There is evidence that online courses and advanced in multimedia technology can lead to innovation in mainstream education, and may even have effects beyond the realm of education itself. Multimedia and online courses therefore may play a decisive role in the creation of the global knowledge-based society (Michael & Tait, 2002).

In education, multimedia tools are used to create stimulating and interactive online education that incorporate audio, video, and animation capabilities. The definition of multimedia has changed over time. According to Ryan and Kasturi (2002), multimedia is defined as the combination of text, graphics, sound, animation, and video with computing technology to provide the user with a multisensory experience. Mayer (2001) states that multimedia are tools or products that utilize computer technology to enable the production, manipulation, and exchange of informative and educational materials to the user. Reed (2003) explained how teachers and students are able to take advantage of multimedia technology to access digital media such as audio, video, and data via the Internet. Walsh and Reese (1995) also discussed the growing popularity of video conferencing via compressed digital video technology. This technology has shown to provide students at different campuses access to live interactive course materials and content.

The impact of multimedia on learning is still a controversial issue. Both quantitative and qualitative studies report positive ideas concerning multimedia-based instruction and its impact on student academic achievement. The effective use of this technology may or may not affect the student's achievement in online courses (Ryan & Kasturi, 2002; Mayer, 2001; Reed, 2003; Vogt, Kumrow, & Kazlaukas, 2001). According to these studies (Ryan & Kasturi, 2002; Mayer, 2001; Reed, 2003; Vogt et al., 2001; Roblyer, 2006; Shelly, Cashman, Gunter, & Gunter, 2004), multimedia components, such as graphics, audio, digital animation, and video, can be integrated into the online courses environment to enhance, engage, and extend the students' ability in understanding course content and materials. An example of this phenomenon can be derived from a study conducted by Mayer (2001), discovering a link between the students ability to understand the course content and motivation to advance further in an online course. From studies conducted by Roblyer (2006) and Shelly, Cashman, Gunter, and Gunter (2004), multimedia can be used as an effective learning tool to help mitigate online course attrition and drop out. Here again you see the concept of motivation and one's ability to grasp the course content in an online course environment. Moreover, multimedia can be combined to produce a visually enriching environment that has the potential to improve the online instruction and facilitate student learning. According to Ryan and Kasturi (2002), the utilization of animation, video, and audio in online courses can be effective in enhancing the students' understanding of vital concepts. Central to the construction of online courses is the concept of instructional design. Instructional design of online courses is particularly significant for courses that have a strong emphasis on visual aspects, such as construction processes or engineering. A meta-analysis study by Liao (1999) examined 35 studies and concluded that multimedia-based instruction is more effective than traditional instruction. However, 10 of the 30 studies showed that traditional instruction is more effective than multimedia-based instruction. Liao (1999) confirmed that multimedia-based instruction has overall positive effects on student learning, but it largely depends on what type of instruction it is being compared to. Dillon and Gabbard (1999) reviewed 30 experimental studies on multimedia effects and found that there was no significant evidence that multimedia improves comprehension. Clark (1983) also viewed that the use of media does not influence student achievement. "It was not the medium that caused the change but rather a curricular reform that accompanied the change. Basically, the choice of vehicle might influence the kind or distributing instruction, but only the content of the vehicle can influence achievement" (Clark, 1983, p. 445). Clark further contended that multimedia is a delivery system for instruction and does not directly influence learning.

Integrating multimedia components in online courses has been a hot topic since its use in education. The issues that have been associated with online courses have been extensive due to the limitations of computer hardware, software, and bandwidth. However, with the rapid advancement of multimedia technology, these issues have become less prominent in online courses. The recent advancement of computer hardware, the increasing number of high-speed Internet connections, and easy-to-use software applications make the process of using multimedia much easier (Ryan & Kasturi, 2002).

CONSIDERATIONS FOR MULTIMEDIA DESIGN

Considering the potential value of multimedia, online instructors need to fully understand the capabilities, limitations, and applications of this technology and prepare for its use in their online courses (Reed, 2003). If multimedia courses are not designed properly, the integration of audio, video, and other multimedia elements will distract rather than enhance Web-based instruction. This point has been shown to adversely affect student-learning outcomes. Mayer (2001) believed that well-designed multimedia online courses can provide an opportunity for students to improve the learning process. Vossen, Maquire, Graham, and Heim (1997) also stated that effective multimedia design involves a systematic and comprehensive approach to analyze the context of use and aspects such as the learner, task, and setting. They identified four elements of multimedia design: content, structure, access, and style.

Multimedia puts high demands on the network, computer hardware, and the user. Preparing multimedia is a time-consuming task and poses big challenges on the instructors. However, it is important for instructors to consider and understand the characteristics of different media formats and the limitations of delivering media in a networked environment. In order to teach online courses effectively, instructors should employ multimedia that is instructional, relevant to the content, and focused on students' learning objectives, rather than merely entertaining (Reed, 2003). The study also showed that if content are not correlated with multimedia, the comprehension rate will be lower. According to Ryan and Kasturi (2002), multimedia should have text, graphic, still images, and video that support interactivity of the conent with the learners. According to Nielson (2000), when instructors incorporate multimedia components in their online courses, they should consider the instructional necessity of the media elements, the accessibility to end user, and technical limitations of the delivery of multimedia content via the online course. For instance, online courses that require high-quality video and audio components, but high-speed networks might perform poorly given the quality and volume of information being downloaded to the local computer. A large multimedia file can be easily downloaded and viewed on campus-networked computer, but it may take a long time to download and view on a student's computer with a dial-up modem connection. Futher, instructors should be aware of the student's computing experience, as well as the limitations of their access to technology including access to high bandwidth, computer hardware, and software (Nielson, 2000). Moreover, if instructors incorporate additional multimedia elements that require special plug-ins or software to view the multimedia elements in their online courses, they should consider two important facts. First, the confusion and annoyance of downloading and installing plug-ins may affect the perceptions of students regarding online course. Second, it is always a good idea to create content within a popular file format. Creating multimedia content in the standard formats for Windows- or Mac-based operating systems and browsers should be considered. Instructors must also explain exactly what software and hardware is needed to operate the online course as well as to view the multimedia components. To take this a step further, the instructor should also provide instructions for installing the specific software if needed (Vossen, Maquire, Graham, & Heim, 1997).

Graphics and animations: Graphics are used to supplement textual content and reinforce concepts derived from the text. Nielson (2000) outlined five functions of graphic illustrations. First, graphics make decorations by making text more appealing and attractive, thus engaging students in content. Second, graphics can represent information in the text such as a person, place, or thing. Third, graphics can help viewers remember key information and recall that information based on the picture word index or induction model. Fourth, graphics can organize information into a memorable structure. Last, graphic illustrations can serve a descriptive function to help reader understand the concepts presented in the text. While we look at the positive notions of the uses of graphics, it is also important to understand the negative. A study conducted by Wetzel, Radtke, and Stern (1994) showed that only 3 of the 16 studies conducted found positive effects of graphic illustration. Eight of the studies reported mixed results for animated graphics. Five of the studies found no effect at all. Therefore, it appears that graphics in themselves present a mixed benefit to student learning. However, Nielson (2000) discovered that graphical elements provide a benefit when they are used to improve learners' understanding of texts by illustrating concepts and organizing textual information and animated graphics. These strategies have increased comprehension and reinforced positive student learning outcomes. It is important to understand that if instructors chose to incorporate graphics and or animation into the content, it may divert readers' concentration and thus hinder the student in their aim to obtain the objectives of the online course (Nielson, 2000). These distractions come in the form of moving text, moving animations, audio and video that do not relate to the text or content. To help with this problem Nielson (2000) and Vossen (1997) suggested that instructors use animations: (1) to draw the learners' attention or alert viewers to new information, (2) to demonstrate navigation in a particular direction, and (3) to create icons for actions that cannot be adequately expressed with a flat, static picture. One of the most popular forms of animation is Macromedia Flash. Because of its ability to produce small file sizes and interactivities, Flash is a very useful media format to incorporate into an online course and to explain concepts visually over dial-up modem connections (Macromedia, 2004). Now with Flash, instructors can incorporate descriptive text to animations, forms, movies, and content that is readily accessible. Soma, Riskin, Harris, Collins, Ngo, and Ferre (2002) discuss the use of Flash animations for online courses. In order to teach using this specific tool, instructors are confronted with the following challenges: (1) providing students with the opportunities to acquire problem-solving skills; (2) providing them with sufficient exercises to practice their skills without using excessive class time; (3) generating effective practice exercises to ensure students' understanding; and (4) offering valuable feedback to all students, which cannot be performed by the instructor. Through Flash animation, animation generates practice exercises that challenge online students to practice their acquired concepts. Once students complete exercises that involve plotting lines from a graph, the computer produces the correct image, while retaining the students' work, thus enabling them to review their work and determine their level of accuracy. In other exercises, students are able to use Flash to see vivid demonstrations of various complex concepts. They are then able to interact with the Web site in a step-by-step process to determine whether they have understood the concepts (Soma et al., 2002). When incorporating Flash animation into online courses, instructors should also inform students to download Flash plug-ins to view this animation.

PowerPoint: Microsoft PowerPoint is another presentation tool that is widely used in online courses. Online instructors can synchronize images, audio, and video with text on PowerPoint slides. Now PowerPoint has become more sophisticated; presentations can be saved as HTML files to use on the Web (Cavanaugh & Cavanaugh, 2000). However, online instructors should be mindful when adding PowerPoint presentations to their courses. The following considerations may help them to incorporate PowerPoint slides (Cavanaugh & Cavanaugh, 2000). It is important to keep in mind that students should have PowerPoint application software or a PowerPoint viewer on their computer in order to view the PowerPoint lectures. If instructors include multimedia elements such as images, sound, and video, it is important to keep the file sizes of these elements as small as possible. File size is a critical issue in the online learning environment. Adobe Photoshop, Sound Forge, and the video editing program Adobe Premiere can optimize video multimedia elements for online delivery. The use of images will motivate students to read the text. However, images included in a presentation must relate to the content. Instructors should decide which type of image is appropriate; otherwise, the image will cause confusion and or distract from the main points presented in the lesson content. When dealing with video, it is recommended not to set video clips to automatically start in a slide, but instead to allow students to choose when to start the video segments. It may also be better to have a small still image to start the video in a window. Sound should be used to enhance the presentation. Avoid repeating sound because it often distracts from the purpose of the presentation. It is recommended that instructors test their presentations on various computer platforms. Different platforms and settings can cause changes in the display of content, and having a different contrast level or changing how the image appears could cause disruption of the presentation.

Streaming video: Video is an efficient way to deliver information. According to Nielson (2000), when instructors add video as an instructional medium in their online courses, they need to use it to enhance the content, rather than to simply deliver it; the video must complement the materials in the online course. Mayer (2001) also stated that video in multimedia-based instruction is an important component, but design issues and the factors that influence the quality of the video must be considered. Streaming video is defined as video data transmission over the Internet network (Reed, 2003). This term implies a one-way data transmission to the users. The user's computer buffers a few seconds of streaming video before it starts sending it to the screen, which compensates for delays. Streaming video allows the learners to view live video over the Internet, and it also allows the server to adjust the streaming video data rate depending on the user's connection status, whether the connection is a high-speed such as DSL and cable modem or a 56K modem (Reed, 2003). The size of video files, compared to that of other data types, is huge. Uncompressed video, such as AVI format video, is composed of 30 frames per second. Each frame has a resolution of 720x486 pixels, which requires almost 170 million bits per second to broadcast. This is a much higher data rate than current Internet technology is capable of sending, so the video file must be compressed to be usable and manageable. A video file that is accessed via the Internet must be compressed (Dixon, 2000). A considerable literature related to the current and potential uses of streaming video exists. In one study conducted at Illinois State University, Hecht and Schoon (1998) used various methods of online courses, including compressed video over the Internet. Using Real streaming technology, they offered the class off campus in both synchronous and asynchronous modes. Students had options to participate in both modes over the Internet. The interactive chat system allowed instructor and students to communicate and to ask questions. However, a number of hardware and software problems were reported. For example, instructors and students had experienced frequent hardware and software failures during the course delivery. Problems such as incompatibilities with computer hardware and software, loss of synchronization between audio and video, and interaction barriers due to audio difficulties were reported. In addition, due to the slow response time, students lost the topic by the time that instructors were talking another topics. Hecht and Schoon (1998) concluded that instructors and students required a huge amount of time to become fluent in the new streaming video technology and encountered unexpected problems. Instructors need more time to prepare their courses for this delivery mode. Technical expertise and willingness on the part of the instructor and students are also needed.

Instruction using streaming video technology may have a negative impact on students' perceptions regarding online courses (Reed, 2003). To overcome the issues and problems regarding streaming video in online courses, instructors need to consider the following points (ION, 2003; Palloff & Pratt, 1999; Reed, 2003). These points may help instructors integrate video streaming in their online courses.

1. Instructors should remember the bandwidth limitations. If students are using Internet on school campus, then streaming video is feasible. They can download streaming video smoothly. However, if they are using home computer with dial-up 56K modems, video and audio quality are not expected to be feasible. Thus, students may perceive the online course as a frustrating delivery mode. If instructors think that motion is not necessary, they may consider an illustrated audio format.
2. Instructors always make sure that students have the latest streaming video software installed on their computer. Currently, three main software formats (RealNetwork's RealVideo, Microsoft's Windows Media Player, and Apple's QuickTime) are available to choose from for viewing streaming video over the Internet.
3. Set the video data rate lower than student's average Internet connection. Because of the compression of the video, the quality will be less than optimal. The important point is that streaming video should be viewable by the viewer's computer.
4. Instructors should always make sure that the streaming video is used to assist students' learning—not to distract.

However, if the adoption of streaming video overcomes barriers such as a lack of high-speed Internet access and minimal technical support, instructors can take advantage of this new streaming video technology to deliver their online courses. As high-speed internet access increases, online courses with streaming video open up many possibilities in online education (Dixon, 2000).

CONCLUSION

Online and Web-based learning environments with multimedia in distance education is growing to meet the needs of the learning population. With advances in Internet, computing technology, multimedia, and Web-based technologies and their ability to reach diverse locations, a diverse program offering can be provided to students throughout the world. The quality of instruction and the effective design of the online course with multimedia will increase as the number of participants and the knowledge exchange among faculty and students. However, it must be understood that the instructional quality of Web-based and online courses with multimedia are critical to the success of the learner and the instructor. Through utilizing the a variety of instructional design principles, online course environment design concepts, multimedia design, and virtual learning scaffolding model, instructors can incorporate multiple instructional routes to include all learners, fostering active and dynamic learning environment.

The findings of the report show that multimedia enhanced instruction involves a great deal conceptual and design knowledge in attempts to develop effective online learning environments where student have the opportunity to fully engage in course materials, content, and course interactivity. By using multimedia within the online course environment, one is able to extend, engage, and enhance course materials and content that may otherwise cause students to have a difficult time learning and understanding the material. Multimedia in the online course environment helps students in their attempts to understand the course materials and connect concepts for further classroom and content engagement. The article presented subject matter that revealed the online learning environment with multimedia would allowed them to be more active participants in their learning process, increasing their critical and creative thinking skills as well as improving their problem-solving skills, if the aspects that affect the instructional quality of the online course were taken into consider and implemented. As a whole, the results obtained in this project were positive and encouraging. The research examined in this article provides educators with the relevant factors to the quality and overall success of the student learning outcomes via online and Web-based courses with multimedia. This method of course design and learning engages students actively in participating in their own learning process, thus leading to the promotion of quality teaching and student learning for a more consistent and dynamic Web-based educational learning environment.

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KEY TERMS

Animation: A simulation of movement created by displaying a series of images through frames. Digital animation is a primary component of multimedia presentations.

Digital Media: Refers to any type of information in digital format including computer-generated text, graphics, and animations, as well as photographs, animation, sound, and video.

ICT: Information and communication technology is the term used to describe exciting and innovative ways to provide lifelong learners with global access to information, learning, and support facilitated through technology.

Instructional Design: Also known as instructional systems design is the analysis of learning needs and systematic development of instruction. Instructional designers often use instructional technology as a method for developing instruction. Instructional design models typically specify a method that, if followed, will facilitate the transfer of knowledge, skills, and attitude to the recipient or acquirer of the instruction.

Multimedia: The presentation of information made with a combination of data, images, animation, sounds, and video.

Online Learning: Instruction and interaction that are primarily based on the technologies available from the Internet and the World Wide Web.

PowerPoint: A presentation authoring software creating graphical presentations with or without audio.

Web-Based Learning: A form of computer-based instruction that uses the World Wide Web as the primary delivery method of information.

Narrative Learning Environments

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INTRODUCTION

Narrative, in the form of stories and narrations, is a natural mode of communication and expression, familiar to children from a very early age and frequently used also by adults. For this reason, it has often been informally employed, both in and outside school, to facilitate understanding and raise learners' interest, therefore supporting learning in both its cognitive and motivational aspects. For a long time, however, narrative was not an object of interest for the educational research. Its first systematic analyses were worked out within humanities studies, characterizing it in several different ways. Some of such definitions already highlight characteristics that appear crucial for its use in education. Ricoeur (1981), for instance, describes it as a sequence of events connected with each other by cause-effect relations supporting the construction of a meaningful totality out of a set of scattered events.

We owe to Bruner (1986, 1990, 1996) the argument that narrative could be a powerful tool to support learning. Following his studies, the literature in education has witnessed a growing interest in narrative. Several authors have underlined the important roles it can play: external knowledge representation (Porter Abbott, 2002); cognitive process (Luckin, Plowman, Laurillard, Stratford, Taylor, & Corben, 2001; Scalise Sugiyama, 2001); sense-making device through the provision of meaningful contexts (Aylett, 2006); organizational principle (Polkinghorne, 1988); and a way to structure human experience, both individually and collectively (Aylett, 2006). As a consequence of this interest to consciously using narrative in education, many different technology-enhanced learning environments (TELE) have been developed, in which a narrative activity plays a central role to facilitate learning. They are called narrative learning environments (NLEs). Based on the literature and on a qualitative analysis of some well-known examples, this article describes the characterizing features of NLEs, highlighting their relation with the learning afforded.

BACKGROUND

The expression NLE was created over a decade ago within the field of artificial intelligence (AI) to indicate interactive environments basing their learning potential on the use of stories. It is not surprising that the concept of NLE first arose in the AI field since this has a long-time tradition as concerns attention to narrative, from early attempts to make computers understand and generate stories in natural language up to the more recent interest to *interactive storytelling* environments, where the users can actively contribute to the creation of computer-generated stories (Mateas & Senger, 1999).

Due to the increasingly widespread interest for narrative, the concept of NLE has successively widened its boundaries to include learning environments of other kinds, originated from research in education-related fields, such as multimedia and instructional design. Multimedia studies gave rise to editors oriented to the construction of stories, as well as to hypermedia environments where a meaningful background story guides the content fruition. Studies in instructional design, on the other hand, influenced the realization of environments including some relevant narrative activity carried out with the use of general-purpose technological tools. The result of such variety of approaches is that currently a very diverse set of learning environments can go under the name of NLEs. Though differing as concerns appearance and mode of use, all of them share the conceptual similarity to support learning by letting the users engage in some narrative-based activity. This fact allows the definition of a unitary framework to analyze their educational impact, as will be explained in the next sections.

Before proceeding, however, we need to point out that not all learning environments including some story can be considered NLEs. Stories are often used in educational programs to provide an appealing background to some unrelated activity without integrating the proposed tasks and the narrative fruition process (Aylett, 2006). This is the case, for instance, of drill-and-practice software tools where some assigned problems must be solved in order to progress through a story. The presence of a story in these cases simply aims to give the learners extrinsic motivation to get engaged in some activity they possibly dislike. It does not facilitate the problem solution on the cognitive level nor does it create intrinsic motivation, that is, help the learners perceive the interest or beauty of the considered learning topic.

THREE CATEGORIES OF NLE

Currently available NLEs can be divided into three main groups, based on the fact that they use very specialized technology (like conversational and intelligent agents), or weakly specialized technology (like multimedia) or general purpose technology (like communication functions) to support a narrative activity. They correspond to the origin of NLEs from different education-related research fields, namely artificial intelligence, multimedia, and instructional design. This subdivision corresponds only to the different kinds of technological tools used: in each of the three groups we find environments with various educational aims and pedagogical orientations as well as addressed to users of different ages and with different learning needs.

NLEs Based on very Specialized Technology

Interactive NLEs allow the users to interact in a nontrivial way with the system to generate consistent narrative. In order to actually realize nontrivial interaction, *intelligent agents* and other AI techniques (Paiva, Machado, & Martinho, 1999) or functions to control nonstandard interfaces need to be used. A variety of environments belong to this group, such as virtual drama and storytelling, educational computer games, as well as *augmented reality* environments, where interaction takes place not only by using standard input/output (I/O) devices but also by manipulating real objects or moving in an *ad hoc* equipped, physical space. Implementing environments of this kind entails working out a solution to a number of technological and conceptual issues. A major one regards making computers automatically generate consistent and believable stories. To this end, researchers have been drawing from narrative theories formulated within narratology studies (Cavazza & Pizzi, 2006) in order to select and suitably develop the constituent elements of a story.

Another important issue to tackle when implementing interactive NLEs concerns the realization of real interactivity between human and virtual agents in the joint construction of narrative. This entails balancing user's freedom and system's intended aims, which entails solving a number of complex conceptual and technical problems. Research in this field has originated a number of different approaches (Paiva, 2005), leading to a variety of solutions for the creation of what is called *emergent narrative*, that is, consistent stories collaboratively created by human–computer interaction (Aylett, 1999).

Several interactive environments were developed in the past decade within a number of research projects; unfortunately, most of them remained in the form of prototypes not widely available. In order to guide the reader to deepen knowledge in this respect, we will mention here the main features of some well known examples, referring to the respective Web sites for more complete information. A longer list of examples can be found at http://nle.noe-kaleidoscope.org/resources/studies.html.

1. Carmen's Bright Ideas is a program designed to help mothers of paediatric cancer patients learn to deal with family problems induced by the child's illness. In this environment, a sequence of stories is offered to the user, featuring two characters, Gina, a counselor, and Carmen, the mother of a sick child. Carmen describes a difficult situation she is currently facing due to her child's illness and is helped by Gina's questions to focus crucial points and to become aware of her own reactions. The user can (partially) determine the next story presented by selecting the kind of problem to be discussed in it. The stories are created by autonomous agents, and a new version of them is generated every time, even if the user suggests the same problem twice. The prospective users are adult women. The expected learning is the acquisition of a more conscious attitude in tackling life problems; learning is induced by creating empathy with the story's main character.
2. FearNot! is an application aiming to prevent aggressive behavior in school by inducing children's affective response against bullying situations. Like in the previous case, a story is presented

to the users, who in this case are primary school children. Some scene of bullying is shown, and at the end, the victim asks the user suggestions on what to do to avoid being bullied again. A natural language interpreter allows the user to express opinions by means of a short personal sentence, based on which a new story is generated by autonomous agents in order to show in practice if the suggestion given is like to produce positive or negative results. The expected learning is the development of some social competence; it is induced by creating empathy with the story's main character and by providing a narrative representation of the user's suggestions.

3. POGO is a virtual story world, accessible through a number of interactive physical tools, aiming to enable primary school children to create stories by connecting the physical and virtual worlds. The expected learning is the development of storytelling and story creation abilities. The environment strongly supports collaborative activity.
4. SAM is an environment designed to let a child practice storytelling with a virtual peer realized by means of a conversational agent. The virtual child, SAM, is projected on a wall and represented in an ambiguous way so as to be possibly perceived as a peer by either boys and girls. SAM and the user take turns in telling stories to each other. The environment includes a toy castle leaning against the projection wall and some plastic figurines, which the user can manipulate while telling stories and then put in a sort of "exchange box" in the toy castle so as to allow SAM to use the figurines on his turn. This allows the user and the virtual child to share objects across the real and virtual worlds. In this environment, there is no collaborative story construction nor real exchange of experiences, in that the natural language understanding implemented is very basic and allows only the recognition of some words that are then used in the next story proposed by SAM. Nor is there any consistency check on the stories told by the user. The simulated exchange of stories between the human and virtual child, however, motivates the user to repeatedly practice storytelling and hence become more fluent in this activity.
5. Teatrix is a 3D virtual environment which allows children to participate in the creation of stories, together with other children or intelligent agents. The activity is organized as on a virtual stage, conceived as intrinsically collaborative and meant to be integrated in classroom activity. Before the performance, the users make some preparatory work, selecting the characters that will appear in the play, the scenes where the action will take place, and the props that will be used. Once the setting is complete, a number of users, logged in on different computers, take part in the story representation by giving life to different characters. Intelligent agents are provided to check the consistence of the characters' behavior and to play the characters included in the plot but not interpreted by any user. The expected learning is the development of story creation and storytelling competence, the choice between creation and telling obviously depending on the task assigned by the teacher.

Environments Exploiting Multimedia Technology

NLEs which sprang from research in multimedia include hypermedia environments with narrative guidance (Luckin et al., 2001), as well as environments based on narrative editors, that is, multimedia editors explicitly (and mostly exclusively) oriented to support the creation of multimedia stories (Earp & Giannetti, 2006). As pointed out in the previous section, hypermedia embodying a narrative can properly be considered NLE only if the given story is related to the learning task at hand. In this case, the learning afforded is related to the fact that a narrative is given to the user, as will be explained in the next section.

Learning environments based on narrative editors, on the other hand, provide features facilitating the construction of multimedia stories, such as predefined backgrounds, characters, props, speech bubbles, and often also voice recording and animation facilities. Unlike most interactive NLEs, which have a well-defined learning content, the environments based on narrative editors are general purpose and can be used to support learning in different fields. Narrative construction, as a matter of fact, can foster expressive abilities (learning *to* tell stories), or allow the user to practice with some particular content knowledge, like using a foreign language or rehearsing knowledge on a historic period (learning *by* telling stories). Analogously, these NLEs do not offer built-in proposals of activities, which means that a teacher or mentor will need to design suitable tasks related to the expected learning. Unlike interactive NLEs, moreover, where some guidance is provided by the presence of "intelligent" functions, these NLEs do not offer automatic guidance to the learner's work. Therefore, a precise didactical planning and guidance by a teacher or mentor is necessary in order to make sure to exploit the educational potential of narrative by guiding the learners to construct stories which are consistent in themselves and with the assigned task.

Narrative editors currently available include both commercial tools (e.g., Story Maker2 [6], Kar2ouche Composer [7], MediaStage [8]), and freeware (e.g., Zimmer Twins [9]). Though all provide rich libraries of elements to create stories, the three mentioned commercial editors differ from each other for the graphics aspect and for offering some different features that make each of them preferable for one or the other kind of applications. StoryMaker appears more suitable for young children than the other ones, not for being less powerful but due to the use of 2D graphics and to the naïf style of the pictures provided. It provides support for a number of European languages, which makes it oriented to language learning. Kar2touch Composer does not allow animations, which forces the learners to rely on dialogues to produce interesting stories; it therefore appears oriented to the development of communication abilities. Finally, Media Stage allows the creation of 3D animation where the end user can move around with some freedom. As concerns the mentioned freeware (Zimmer Twins), it provides a rich menu of actions that the three characters allowed can perform, hence highlighting one of the distinctive aspects of narrative, that is, to concern actions, not simply descriptions of situations.

NLE Based on General Purpose Software

The literature offers a variety of examples of NLE which make use of general purpose software and envisage some relevant narrative task within the overall design of an articulated learning activity. NLEs of this kind are characterized by a strong human component, since the use of only general-purpose software makes their consistency and efficacy completely depend on human planning and monitoring. They share with most interactive NLEs a specialization in their purpose, since a learning task and some learning activities must always be specified to define them. They often (but not exclusively) make use of narrations of experienced or observed events, rather than of invented stories, used as a starting point to stimulate reflection and comparison on a concrete ground.

An example is provided by De Vries (2006) who reports a case study where primary school children develop and share with peers experiential narrations of their science classes. In this environment, the narration of the learning activities carried out in the science class aims to stimulate reflective thinking, hence to improve learning. The technology employed is e-mail, used to share the narrations with the pupils of another school. The communication phase amplifies the impact of narration construction by giving the pupils a concrete public for their productions and hence motivating the need to work with particular care.

Another example of this kind of NLE is offered by Dolk and Den Hertog (2006) who challenge trainee teachers to collaboratively develop narrations of paradigmatic classroom situations after watching videos on them. The fact of constructing collective narrations of the watched situations before reflecting on them makes the reflection phase start on a concrete and shared basis, avoiding possible (and frequent!) misunderstandings due to inaccurate observation of the proposed situation. The technology used in this case is a software to show videos; its role is to allow repeated observations of the proposed situations, hence leading to the construction of more accurate narrations. The expected learning is to improve observation abilities.

ASPECTS OF NLE INFLUENCING LEARNING

Narrative can be used in many different ways within learning environments. Its mode of use determines how its educational potential is exploited and consequently what learning is afforded by a narrative environment. Three factors appear particularly relevant in determining narrative's influence on learning, namely the role of the user with respect to the narrative, the technological means used to generate, share or receive it, and the learning approach underlying the proposed narrative activity. The most often implemented learning approaches include game-based, challenge-based, case-based, and situated learning, problem solving, empathy driven learning. All of them imply a constructivist general orientation, which is not surprising, since NLEs always entail some kind of activity by the user. The learning induced by the user role and by the technology used deserve a wider discussion, which is the object of the following subsections.

Role of the User

In NLEs, the student can be given a narrative or asked to produce one. *Giving a narrative* helps make sense of problem situations, with the aim to improve understanding or to facilitate problem solving. Often, the story provided acts as a container highlighting the elements of a considered problem situation and helping the user relate them with each other in a meaning-creation process which is functional to the construction of a solution. Receiving a story created and told by others stimulates understanding, in that it implies a cognitive activity consisting in elaborating a mental representation of the narrated facts and of the causal and temporal connections among them. As concerns problem solving, a given story may provide a guidance to the exploration of a hypermedia environment, like in the Galapagos environment (Luckin et al., 2005); help the user understand the nature of a problem, like in the FearNot! (Aylett, 2006); or help the learner understand the relation among a problem's data, like world problems in mathematics education. *Story production* may take place in different ways, namely by creating, telling, or participating in story creation. Each of these possibilities puts into play different abilities. Story *creation* entails that the learner invents a story, possibly starting from some given elements (e.g., a story involving some particular character or set up in a particular context) or with some constraints (e.g., a story to illustrate some moral or general fact, like in Aesop's fables). Such activity stimulates creativity; it also encourages logical reasoning, in that stories must satisfy constraints of consistence as well as of temporal and cause–effect relations.

Story *telling*, on the other hand, entails reporting a story created by somebody else. This puts into play memory and the ability to express a known story in personal way, yet preserving the original content and meaning. Both story creation and telling can be carried out individually or in cooperation with some other learner, which entails that the overall development of the story must be negotiated among the subjects involved.

Finally, when *participating* in story creation, each (human or virtual) agent involved gives life to a different character, and the narrative raises from the actions individually performed by all of them. This activity stimulates creativity like individual story creation, but results more demanding on the logical level since the consistency checks are made more complex by the need to control one's character in an overall framework that integrates the ideas of all participants. A particular case is role play, where the participants interpret characters with assigned features that constrain and characterize their behavior.

Technological Means

The development of ICT and its increasing use in education has provided a variety of tools and techniques—from 3D graphics and animation to intelligent agents, from communication means to augmented reality—apt to exploit and strengthen the use of stories. Not only do the technological means used influence the appearance and operation of an environment, they also determine what kind of activities can be carried out, and hence the learning afforded. An increasing number of studies on technology-enhanced narrative environments has highlighted that the use of different media (Decortis, Rizzo, & Saudelli, 2003; Fusai, Saudelli, Marti, Decortis, & Rizzo, 2003) and of technological tools (Aylett, 2006) affects the learning affordance of an environment so that the ICT tools employed determines what cognitive activities can be carried out and hence what learning is likely to take place. Moreover, ICT tools facilitate the creation and use of multimedia narratives, including nonverbal ones (or with a very limited amount of verbal language), made of sequences of scenes, like movies or cartoon strips. This allows even people with language-related learning disabilities to carry out educational activities which exploit the learning potential of narrative (e.g., Faux, 2006).

As an example of the different learning afforded by environments with similar aims but based on different technologies, let us consider Teatrix [10] and StoryMaker2 [11], both of which can be used to create stories (Dettori & Giannetti, 2006a, 2006b). In Teatrix, which implements Propp's narrative theory (1968), the characters available are limited to eight different kinds and can take a limited number of well-defined roles. This means that they are completed by a description which constrains their possible behavior. Hence, story creation in this environment actually results in a role-play activity. Teatrix, moreover, includes an intelligent function (the *hot-seating*) which detects inconsistencies in characters' behavior and monitors the overall coherence of the story. This environment, therefore, strongly supports the development of a narrative competence, in particular as concerns causal reasoning.

StoryMaker2, on the other hand, is oriented to support the practice of communication skills and is not based on any narrative theory. It offers a library of backgrounds, props, and characters which is much richer than that provided by Teatrix, as well as more complex animations and a more refined graphics. It also allows the user to import images and sounds from external files and to record spoken language. All these features can support the creation of more articulated and fancy stories than in Teatrix, and also favor the acquisition of a technological literacy in relation with multimedia expressive competence. This comparison highlights that the different technological tools used in the two environments actually lead to structure and develop the experience of story creation in different ways.

CONCLUSION

NLE is an emerging field. Attention to the use of narrative to support learning is rapidly increasing, and we can expect a fast growth of its research and diffusion of its applications. Several issues should be addressed to further develop the field:

- From a conceptual point of view, the relation between narrative, technology, and learning should be deepened, and particular cases of NLE should be explored so as to define more precisely the limits and structure of the field.
- From a technical point of view, more effective, efficient, and interactive environments should be built, trying to bridge the three mentioned groups of NLE.
- From a pedagogical point of view, the impact of applying NLEs in different disciplines, including nontraditional ones, like the scientific domain, should be analyzed, and their educational potential further explored.

Moreover, particular attention should be given to two important issues that are transversal across the conceptual, technical, and pedagogical, that is, evaluation and diffusion of applications. Evaluation is a complex task, since several different aspects should be taken into consideration, such as educational effectiveness, modes of interaction afforded, influence on students' learning competence, and appreciation of the narrative experience. As concerns the diffusion of applications, attention should be paid to preparing teachers to effectively make use of this kind of environment and to support the transformation of many interesting proposals from the state of prototypes developed within research projects to that of widely available products (Aylett, 2006).

ACKNOWLEDGMENT

This work was carried out within the Special Interest Group "Narrative and Learning Environments" [12] of the European network of excellence Kaleidoscope [13].

NOTES

1. http://www.isi.edu/isd/carte/proj_parented/
2. http://info.nicve.salford.ac.uk/victec/
3. http://www.iku.ulg.ac.be/projets_5_en.htm
4. http://www.media.mit.edu/gnl/projects/castlemate/
5. http://gaips.inesc-id.pt/teatrix
6. http://www.spasoft.co.uk/storymaker.html
7. http://www.mediastage.net/kar2ouche/
8. http://www.mediastage.net/mediastage/
9. http://www.zimmertwins.com
10. See reference in the previous section.
11. See reference in the previous section.
12. http://nle.noe-kaleidoscope.org/
13. http://www.noe-kaleidoscope.org/

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KEY TERMS

Autonomous Agents: These are Artificial Intelligence procedures having internal goals to achieve and able to make decisions on the actions to execute, without direct human intervention. They are typically used to implement virtual characters in interactive narrative learning environments.

Narrative: This word is used in the educational field to mean stories and narrations. Narrative is currently recognized as a valid support to learning in both its cognitive and motivational aspects, in the wake of the work of Bruner, which highlighted its cognitive value as sense-making device and its motivational potential raising from the fact that it is a natural form of expression and communication among people of all ages and all cultures.

Narrative Editors: These are multimedia editors explicitly (and, often, exclusively) oriented to the creation of stories made of a sequence of pictures or scenes completed by textual (written or spoken) parts, as in cartoon strips and movies. To facilitate story construction, such editors provide collections of predefined backgrounds, characters, props, speech bubbles and often also voice recording and animation functions.

Narrative Learning Environments (NLE): These are learning environments where the user gets engaged in some learning activity in which a story plays a central role to facilitate learning. In such environments, a story can be given to the learners or be constructed by them. In the first case, the given story helps the learners build an overall mental picture of a problem situation, highlighting the role and relation of the different data involved. In the second case, the construction of a story by the learners aims to facilitate the acquisition of some competence, e.g. expression abilities, in mother tongue or in a foreign language, various subject matters and soft skills. A variety of ICT tools can be used in NLEs to amplify the learning potential of stories, by speeding up their creation or facilitating their fruition. Such tools can range from general-purpose software (like email) to weakly specialized one (like narrative editors), and up to very specialized one (like conversational and autonomous agents).

Technology Enhanced Learning Environment (TELE): This term refers to learning environments where ICT tools are used to support and facilitate learning. Technology, however, is not the focus of the learning process, nor is it all a student needs to learn in such environments. The TELE is rather a scenario comprising learning objectives, tasks, learning materials, tutors, teachers, other students and technology. In this scenario learners can play an active role in their own learning process.

NETRIC: A Proposed System for Synthesis of Multicast Transport Protocols

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INTRODUCTION

The article presents a proposed method to select an optimal set of the multicast protocol parameters, which are linearly independent from each other. A multidimensional hyperspace, as a mathematical model, is stated where every transport protocol parameter is represented with an individual point. A determined novel protocol parameter set is shown and the modeling procedure is presented on some examples. A multicast transport simulator has been applied to describe the performance of the transport protocols and for optimization of the parameters, providing the most reliable multicasting operation.

BACKGROUND

Reliability is one of the most important features of all multimedia applications. This requirement may be especially critical in the case of multicast, where because of the large volume of data to be transferred, the correction or resending of lost data will be even more difficult in time (Hosszú, 2005).

The multimedia applications generally support the one-to-many group communication way. For this purpose, the IP-multicast transport mechanism is preferable (McCanne, 1997). However, the IP-multicast itself cannot guarantee any reliability because of the well-known best-effort delivery of the IP network. In order to increase the reliability for the data distribution or interactive media applications, reliable multicast transport protocols are necessary. However, the unicast TCP does not support the multicast and, on the other hand, the UDP does not provide any reliability (Yu, 2001). For this reason, additional multicast transport protocols are used to achieve the required level of reliability (Obraczka, 1998).

The various media applications, as the distributed collaborative multimedia systems, data dissemination tools, and real-time media streaming software require various multicast transport protocols to obtain optimal performance. The transport protocols have a lot of different property attributes of the data delivery. Such properties are the *flow control*, the *congestion control*, the *data- and the time-reliability*, the *packet ordering*, the *state control*, the *acknowledgment control*, the *scalability of the repair requests*, and so forth. These attributes can be represented by a selected set of the now introduced so called *protocol parameters* (Hosszú, 2005). Each protocol parameter describes different reliability mechanisms for the same delivery attribute. A protocol parameter is, for instance, the repair method, which can get the values such as the retransmission, the forward-error correction, the interleaving or the different ways of the local receiver-based repairs. Another parameter is the acknowledgment type, the possible values of which may be tree-based, ring-based, or a simple direct form (Levine & Garcia-Luna-Aceves, 1998).

An attempt to classify these protocol attributes was published by the IETF Reliable Multicast Transport Working Group (RMTWG) in Handley, Whetten, Kermode, Floyd, Vicisano, and Luby (2000) and Whetten, Vicisano, Kermode, Handley, Floyd, and Luby (2001), introducing the "*building blocks*" for multicast protocols, where these building blocks can be considered mostly equivalent with the protocol parameters. The use of building blocks is reasonable because of the intention to make the work of a protocol-designer easier. Our approach shows that the idea of partitioning protocols based on their parameters is good and can serve the base of further research.

In the transport area, the RMTWG defines some design criteria for the building blocks connected to topics like the data content model, the group membership dynamics, the sender/receiver relationship, the group size, the data delivery performance, and the network topology with or without router level intermediate system assistance. The protocols are divided into three families, on the grounds of their realization-bases: NACK based protocols, Tree-based ACK protocols, and an "Asynchronous Layered Coding Protocol" that uses Forward Error Correction. All building blocks can be used to develop a new protocol belonging to these three protocol families, so the work of a protocol-designer gets easier.

However, all work described above has been made in only one direction, especially based on the requirements of such applications that use one-to-many bulk data transfer. This could mean a limit for the usability of this approach, just as for defining all of the protocol parameters. In the novel NETRIC protocol analyzer and synthesizer system, a most universal interpretation of these protocol parameters was applied, constructing an *orthogonal hyperspace* of these. This assembly of parameters allows applying well known mathematical methods for optimization in order to select an individual point on this space providing the optimum set of multicast protocol parameters. However, the specification of the parameters can be done with compatibility to the building blocks.

The design process of the building blocks was done from a functionality based point of view, but the NETRIC system uses the mechanism-based approach. The aim of the building blocks is creating a development framework in order to help the developers. In the NETRIC system, we use existing mechanisms and try to select the best collection of mechanisms to implement. The building block-based approach is focused on development and needs human assistance during the process; however, we concentrate on simulation and selection. We try to create an automated process, which can automatically determine the right solution. Their productivity differs in the various using areas. For example, a building block-based development is more productive for new types of services, but NETRIC is better for fine tuning existing, well known protocols in different environments.

METHOD

The main goal of the NETRIC project is, as mentioned, the optimization of the protocol parameters in order to improve multicast reliability. However, applying any appropriate mathematical optimization method, the selection of the protocol parameters mentioned above must be carried out to provide a *linearly independent* (in other words, orthogonal) set of parameters. Selecting these protocol parameters, basically a hyperspace of the parameters is created where all transport protocol corresponds to one point of this space (Hosszú, 2005). The optimization procedure means to find the most suitable point on this space to provide the best performances of multicast. The modeling procedure based on the introduced protocol parameter set is presented on some examples (Handley et al., 2000). The strangeness of this orthogonality may be weakened, as discussed later.

To carry out a correct optimization procedure on the appropriately selected protocol parameters, a well usable simulation program should be applied in order to present statistically acceptable results for multicast data transfer. This problem has been solved by the multicast simulator SimCast (Orosz & Tegze, 2001), which describes the performance of the transport protocols (Whetten et al., 2001). The simulator has a modular architecture, which makes it possible to choose from the alternative mechanisms of each protocol parameter.

The system presented does iteration loops with the multicast transport protocol parameters in order to satisfy the requirements of the upper layer media applications. The synthesis is done by designating the protocol parameters and determining the range of them, based on the results of the simulation loops. Using

Table 1. The 31 protocol parameters

Category	Protocol parameters
Data traffic control	Transmission way, Transmission direction, Congestion prevention, Flow control
Delivery control	Data accuracy, Time limitation, Scheduling, Updating, Ordering
Feedback management	Acknowledgment types, Feedback addressee, Election of the designated host, State control, Feedback control, Way of feedbacking
Repair management	Request way, Repair method, Repair source, Repair selection, Way of sending repair, Repair scoping, Repair control
Session management	Session control, Floor control, Membership control, Locus of control, Scalability, Group stability
Network demand	Bandwidth demand, Network heterogeneity, Direction dependency

this simulator, an optimized transport protocol can be synthesized, satisfying the requirements of a certain media application. This means that by a mathematical method, an optimal point in the hyperspace of the protocol parameters can be found.

THE HYPERSPACE OF THE TRANSPORT PROTOCOLS

The possible values of protocol parameters (which are the types of various mechanisms as the components of the transport protocols) are the realizations of each protocol functionality. Table 1 shows a possible set of 31 different protocol parameters and their classification into categories. The protocol parameters represent the well-known reliable mechanisms of the transport protocols (Obraczka, 1998).

The orthogonality is defined in the Euclidean space. Let E_ν be the ν-dimension Euclidean space, where each point is in the space is in fact a ν-dimensional vector. The $V_1, V_2, \ldots, V_\nu$ vectors are members of the E_ν space. The $\{V_1, V_2, \ldots, V_\nu\}$ vectors are orthogonal if the following equation is true.

$$\left(V_i, V_j\right) = 0 \quad for \ \forall\, 1 \le i, j \le \nu ,$$

where (V_i,V_j) is the scalar product of the vectors V_i, Vj and ν is the dimension of the E_ν space. In our case, ν=31.

Each multicast transport protocol parameter can be transformed to different $\{V_1, V_2, \ldots, V_\nu\}$ vectors of the E_ν Euclidean space.

For an individual application, the protocol parameters get actual values. In order to optimize a transport protocol, the optimal point should be found in the 31-dimensional *hyperspace of the protocol parameters*. The optimization procedure can be executed easily if the applied protocol parameters are orthogonal to each other. Orthogonality means that any of them can be changed independently from the others. Since the selection of the applied protocol parameters is very important, the task is to obtain a complete set of the protocol parameters, which can be taken as orthogonal. For the current set of the 31-protocol parameters, the orthogonality is not completely satisfied, but because of the fact that the importance of different protocol parameters are highly different, it can be used. A *quasi-orthogonal* subset of the protocol parameters and their possible values is presented in the Table 2.

The protocol parameter *flow control* means the prevention of the receivers against the overload. The *data accuracy* is *reliable* if there is a mechanism in the protocol for loss recovery, and it is *atomic* if the protocol provides exactly the same data for all receivers. The *feedback addressee* is the host which receives the positive or negative acknowledgments.

The *state control* parameter defines the responsibility for loss detection. The *feedback control* means the prevention of the feedback address host against the feedback implosion. The *way of sending repair* determines the applied transporting mechanism. The *scope of repair* describes the responsibility of the repairing source, which can be global or local. If its responsibility is global, it can send packets to every member,

Table 2. The selected subset of the protocol parameters and their values

Protocol parameters	Values
Flow control	Window-based, Rate-based, Multigroup multicast, Receiver give-up, None
Data accuracy	Reliable, Atomic, Unreliable
Feedback addressee	Original source, Intermediate host, Every member, None
State control	Sender-based, Receiver-based, Shared, None
Feedback control	Structure-based, Timer-based, Representatives-based, Rate-based, None
Way of sending repair	Unicast, Multicast, None
Scope of repair	Global, Global to secondary group, Global to individual members, Local, None
Session membership control	Explicit, Implicit, None

Table 3. Actual protocol parameter values of four transport protocols

Protocol parameters	TRM	LBRM	LRMP	RAMP
Flow control	Window-based	None	Rate-based	Rate-based
Data accuracy	Reliable	Reliable	Reliable	Nonreliable
Feedback addressee	Original source	Intermediate host	Every member	Original source
State control	Receiver-based	Receiver-based	Receiver-based	Receiver-based
Feedback control	Timer-based	Representatives-based	Timer-based	None
Way of sending repair	Multicast	Unicast or Multicast	Multicast	Unicast or Multicast
Scope of repair	Global	Global to individual members or Local	Local	Global to individual members or Global
Session membership control	Implicit	Implicit	Implicit	Explicit

to a subset of the whole group (secondary group), or even to individuals only. Finally, the parameter *session membership control* describes the handling method of hosts, which want to join to the session. This protocol parameter is explicit if the members of the session are registered and implicit if they are not.

The selected parameters are quasi-orthogonal only, since there are trivial cases where the orthogonality cannot be satisfied. For example, if there is no feedback, then the protocol parameters *feedback addressee* and *feedback control* will be none. However, if the *feedback control* parameter is none, the *feedback addressee* is not obviously none, as Table 3 shows, where the actual protocol parameter values of four transport protocols are displayed.

The presented transport protocols are TRM: Transport protocol for Reliable Multicast (Sabata et al., 1996); LBRM: Log-Based Reliable Multicast (LBRM) protocol (Holbrook et al., 1995); LRMP: Light-weight Reliable Multicast Protocol (Liao, 1996); and RAMP: Reliable Adaptive Multicast Protocol (Koifman & Zabele, 1996). All of the presented transport protocols have receiver-based state control. The reason of the orthogonality of the protocol parameters is that the background mechanisms are independent from each other.

APPLICATION OF THE SIMULATOR

Most of the formal protocol evaluation methods published in the literature are restricted to a limited set of protocols, mostly to one only. Consequently, these optimizations are performed on the protocol mechanisms fitting their attributes of conditions of the actual network and the requirements of the applications. However, the comprehensive selection of the protocol mechanisms during the optimization should lead to better results. The multicast transport simulator for multicast (SimCast) has been developed earlier to describe the performance of the transport protocols (Orosz & Tegze, 2001).

The SimCast simulator contains a network layer model that can create a distribution tree. However, the SimCast can also use the output of other network simulators, including the multicast distribution tree created by them. Its reason is that the SimCast is developed first of all for evaluating the transport protocols, and the performance of the delivery based on these protocols are partly independent from the underlying network. Modifications have been made on the SimCast simulator in order to achieve a better usability of it in the NETRIC system.

The architecture of the simulator SimCast is shown in Figure 1. By using the configuration files, the Manager object loads in the network topology and the program calculates the routing information for this topology. The Transmitter object determines the datagrams to be sent to the distribution tree on the basis of the configuration file of the data traffic. In the next step, the Scheduler object controls the scheduling, which is nonpreemptive. The Scheduler sends a message in each simulation time point to all routers, hosts, and transmitter objects. Receiving these messages, the objects calculate their states in the next time point and, if it is necessary, they communicate with other objects (e.g., sending a package). The Scheduler updates the display in each simulation time point. The objects, which participate in the simulation, are in relation with the Logger object, which logs the saturation of the nodes and transmission of the packages, respectively.

The simulator needs three kinds of inputs, namely the network topology, the parameters of the multicast delivery, and the input datagrams to be transmitted. In order to define the network topology, the routers, links, and hosts must be configured with the appropriate attributes. In the case of routers, the necessary parameters are the network address and the packet FIFO size and, furthermore, the processing speed of the router and the position of the network topology schematic on the display. The network layer address is composed of the identifier in the local network and the local address of the host or router. This is a simplified model compared to the IP addressing system; however, for performing the simulation, the differentiation of the various IP address classes is not necessary.

Figure 1. The structure of the simulation process in the SimCast

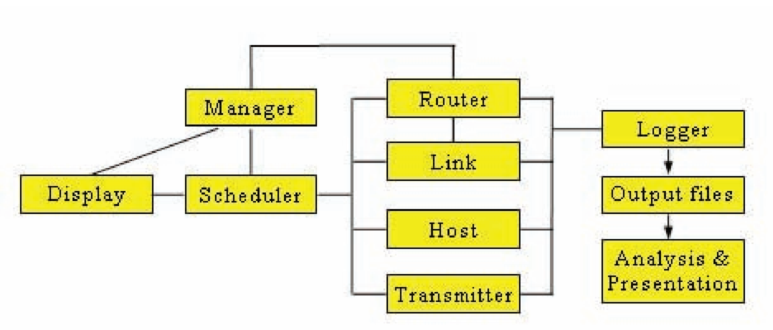
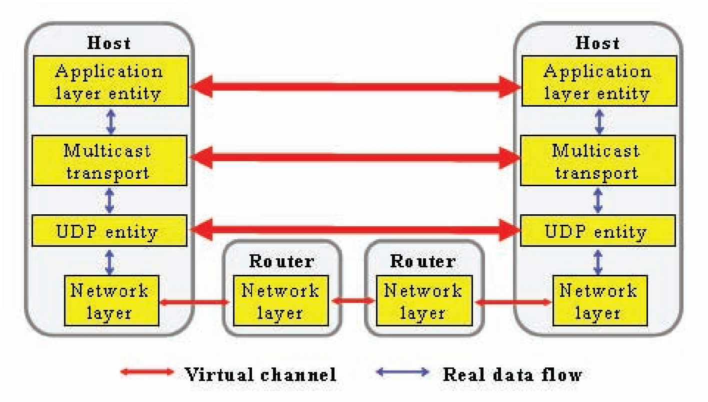


Figure 2. The data transmission among the protocol entities



In the configuration of the host, the attributes are similar to the parameters of the routers, with the only difference that in this case no parameter representing the speed of the router is necessary. If the addressee of the packet to be transmitted is in the LAN of the actual host, the packet is delivered directly to the addressee; otherwise the sender sends the packet to the local router, which takes care of the delivery to the destination. The local identifier part of the network address is 0 in the case of routers and a number larger than 1 for hosts. In the case of links, the following parameters should be defined: the network addressees of the two routers to be connected, the delay parameter of the link, and a flag of the availability of the connection. The delay parameters are used in the case of routing information.

In the multicast simulation, the packets are ordered, and so the packet can be trace-routed on the basis of the output files. The packets arrive to the FIFO of the routers or hosts, which forward the first arrived packets first. The routers forward the packets to other routers or hosts, and finally, the network layer protocol entities of the receiving hosts forward them to its higher layer protocol entity (see Figure 2).

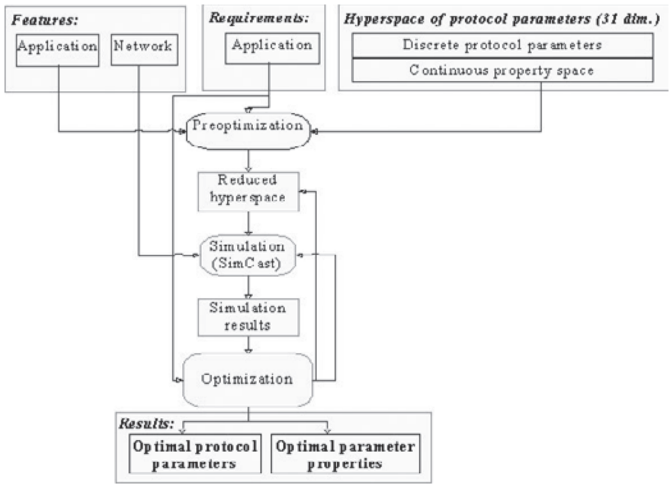
The processing time of the packet depends on the speed of the router, which is defined in the network configuration file, and the size of the packet, which on the other hand is defined in the configuration file of the data traffic. A packet loss can appear if the FIFO of the destination machine becomes full. In the simulator, the hosts use negative acknowledgment to request retransmission. The routers and the hosts register the serial number of the latest successfully sent package. If the serial number of the arriving package is less than the expected value, the router forwards the package on the distribution tree, since it is possible that the actual package is a repair one to another node. If the serial number equals the weighted value, the router forwards the package, too, and it modifies its registry of the serial number of the latest successfully received package. If the serial number is larger than the expected value, the router drops the package.

THE GLOBAL STRUCTURE OF THE SYSTEM

The NETRIC system can be used to automate the process of designing a new multicast protocol, based on the requirements of a specific application. The automation means that not only can the optimal values of a set of protocol parameters be determined, but the optimal value of these protocol parameters can be determined, too.

As seen before, discrete set of protocol parameters can be defined based on the existing transport protocols, and the property space of these parameters can also be declared. In order to achieve the best protocol for a specific application, we use these parameters as elements and try to determine the optimal set of protocol parameters and the properties of them. Figure 3 shows the structure of the NETRIC system.

Figure 3. The NETRIC process



After a simple, rule based pre-optimization, we get a reduced hyperspace of protocol parameters, which can be used as the input of the simulator. The SimCast simulator takes the information about the parameters of the network and the reduced hyperspace and does the simulation with the information of the features of the application. The results serve as the base of an optimization method, which can act back to the set of protocol parameters (for example, prohibiting some of them), or only to the simulation (setting some parameter properties). At the end of the simulation-optimization loop, we will get the set of the optimal protocol parameters and the optimal properties of these parameters. At the end of the optimization, the system NETRIC carries out the optimal values of the given set of protocol parameters.

CONCLUSION

The transport protocols improve the reliability of the IP multicast delivery. The development of such protocols needs the knowledge of the fundamental transport mechanisms. In this article, a decomposition of multicast transport protocols into various protocol mechanisms was presented. The protocol mechanisms belonging to the same functionality form the possible values of so-called protocol parameters, which can be taken as quasi-orthogonals. On the basis of the protocol parameters, a novel protocol classification way can be carried out, which is used in the NETRIC protocol analyzer and synthesizer system. By using the presented model of the transport mechanisms and the NETRIC synthesizer, the design and the verification of new multicast transport protocols can be improved.

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KEY TERMS

DNS (Domain Name System): Hierarchical distributed database for mapping the IP addresses to segmented name structure and vice versa.

Hyperspace of Protocol Parameters: This abstract space is composed of the possible values of each property of the multicast transport protocols. The values represent various protocol mechanisms.

IETF (Internet Engineering Task Force): A voluntary association for developing Internet standards.

Internet Protocol (IP): The network-level protocol used in the Internet.

IP-Multicast: Network-level multicast technology, which uses the special class-D IP-address range. It requires multicast routing protocols in the network routers. Its other name is ***network-level multicast*** **(NLM)**.

Multicast: One-to-many and many-to-many communication way among computers (hosts).

Multicast routing protocol: In order to forward the multicast packets, the routers have to create multicast routing tables using multicast routing protocols.

Multicast Transport Protocol: To improve the reliability of the multicast delivery, special transport protocols are used in addition to the unreliable User Datagram Protocol (UDP).

RFC (Request for Comments): The IETF publish them as de facto standards of the Internet.

TTL (Time-to-Live): A field in the IP packet header. Its value is the allowed hop-count, the number of routers, which can forward the packet before delivery or dropping out.

Unicast Transport Protocol: They handle the ports in each computer or improve the reliability of the unicast communication. As examples, the User Datagram Protocol (UDP) is a simple unicast transport protocol mainly for port-handling, and the Transmission Control Protocol (TCP) is intended for reliable file transfer.

Unicast: The one-to-one communication way, where only one host transfers data with another host. In the traditional IP, the unicast is applied.

Network Management Resource Costs

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INTRODUCTION

The reliance on computer communications networks for business and commerce, education, entertainment and many other applications demands these resources are managed effectively. In this context, "management" refers to ensuring security and performance, recovering from faults and accounting for utilisation. Each of these activities requires knowledge of the network configuration, and information about the networked devices. It is on the basis of this knowledge that management decisions to change the configuration and network behaviour are taken. Hence the manager requires as full and accurate a set of information about the network under their control as it is possible to get. Typically, this information resides across the network and is transferred (to the network manager) to assist the network manager's decision making.

Therefore, network management creates network traffic and consumes network resources, as information is collected, transferred, and processed, and commands move to their required destinations. Because a typical computer network uses the same network facilities, data links, processors, network interfaces, switch, and router storage as ordinary user data, the management process must be efficient. Resources consumed by network management activity: bandwidth, processor time, and data storage space are not available to "real" network users and hence have a direct impact on the level of service experienced by users. Historically, this has meant network management designs being constrained to a greater or lesser extent by their resource consumption, and one development aim is often to deliver an effective network management service with as little resource consumption as possible. Indeed, proponents of particular network management paradigms, particularly the first version of the *de facto* standard Simple Network Management Protocol (SNMPv1) (Case, Fedor, Schoffstall, & Davin, 1990), made much of the minimal resource demands of their design. More recently, other network management proposals often use SNMPv1 as a benchmark for comparative resource consumption.

It is therefore appropriate to consider the resource impacts of different network management paradigms to gauge likely effects on networks they manage. In this chapter, we identify the characteristics of various network management systems, describe how the ways in which these tools are used by a network manager generate work (traffic and processing loads) for the network, consider appropriate ways to measure their behaviour, and discuss performance data.

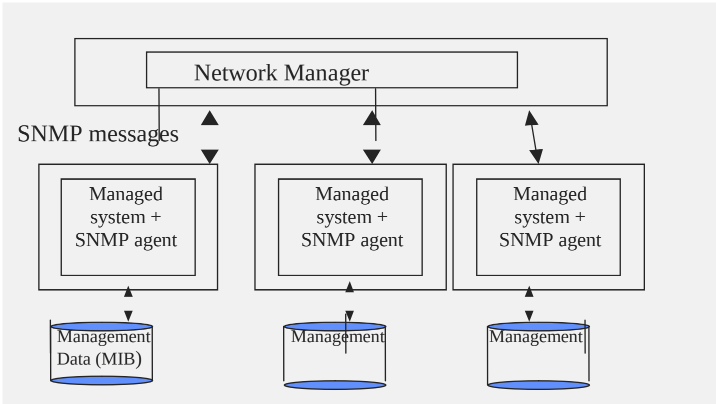
NETWORK MANAGEMENT: AN OVERVIEW

The history of network management in the form discussed here starts in the late 1970s, with standard protocols to monitor network devices, first gateway devices and later network host systems and interconnection devices. It is important to realise that in typical computer communications networks (e.g., a TCP/IP based system), the same physical network carries both user and management data. This differs from the telecommunications approach of a separate "management network." Hence, in computer networks, managers and users share and compete for bandwidth, processing, and storage capacity.

Client-Server Based Network Management

In its simplest, in a deployment model exemplified by SNMPv1, a single, central network management platform receives information from network devices by "agent" programs resident on the devices in response to management platform requests. The data are then collated and presented to the (human) network manager (Figure 1). This simple client-server, single point of concentration approach creates a single point of failure or loading, since more management data are generated

Figure 1. SNMP in a centralised system



in emergencies, possibly making the original problem even worse.

The Search for Alternatives

Concerns over data volume and concentration have led researchers to explore alternatives. In particular, addressing the problem of the quantity of data transferred created improvements in the effective payload of SNMP, version 2's bulk transfer operation among the most significant. Other proposals reduced the volume of data by *preprocessing*, introducing a hierarchy of managers so the required data need not travel so far with decisions taken nearer the point of impact.

More Resource-Intensive Management Support

With increases in processing and communication capability, network management approaches are less driven by resource conservation. Version 3 of SNMP (Frye, Levi, Routhier, & Wijnen, 2003) is a good example. The imperative for security in the network management function means strong authentication and encryption have become part of the protocol. Clearly, the added processing and data transfer increases the resource requirements, as will be discussed later in this article. Finally, the 2004 announcement (Pras et al., 2004) that SNMP-based network management is likely to be superseded by systems based on XML further increases the processing and bandwidth requirements of network management.

Device Capability

Resources consumed by network management are not available for users; therefore, designers have attempted to minimise network management's impact. For example, deploying SNMP agents across network devices (workstations, servers, printers, etc.) makes it desirable to keep management functions simple. Arguably, developments in processor power make this less significant with the extra power available even in "basic" components allowing more complex functions. Running counter to this is the drive for greater network management support deployed to ever more devices and the wish to have mobile devices in a network. The fact that these devices often have limited (battery) power makes simplicity and resource efficiency desirable goals. A further driver is the wish to limit power consumption on mains-powered networking devices, since keeping devices "on" solely for network management is inefficient. These issues and the development of so-called power saving network management architectures are outside the scope of this article, though we are currently pursuing research in that area.

PERFORMANCE ISSUES

Our discussion of measuring performance begins with a definition of the performance parameters used. Standard measures of a communications system's performance are speed (the rate at which it carries information) and accuracy (the proportion of errors or losses and reliability, or availability, the probability of it being accessible when required). For higher level communications protocols, it is appropriate to study processing and storage requirements of the support software. Speed is clearly important in most evaluations. Here, management decisions have to be taken quickly (to minimise damage from faults or security problems), underlining the need for rapid delivery of relevant data. Application protocols assume accuracy and reliability are provided by supporting network protocols. However, the resource requirements to process management information and commands do affect the efficiency of any method. Therefore, the work described in subsequent sections will concentrate on the following comparators:

- **Bandwidth utilisation:** As bandwidth is a finite resource (albeit with upper limits significantly higher than in the past), any bandwidth consumed by network management is not then available for user data.
- **Data requirements:** Volumes of data transferred to meet a particular management activity provide further measures of resource requirement for that activity. Whereas bandwidth measures the rate of data, this volume calculation indicates the activity's efficiency.
- **Processing requirements:** Measures the tasks' complexity. Sometimes processing is split (e.g., between client and server); otherwise (mobile agents) processing is done by local devices. Generally, an activity's overall processing needs to remain comparable, irrespective of where the work is done; however, a measure of relative processing costs is useful in optimising the processing load.

RESULTS

In this section, we discuss the performance of different network management approaches. The first standard network management protocol, SNMPv1, still in widespread deployment despite its age, is used as a baseline for comparison with mobile agent-based management activities, identifying the potential benefits and drawbacks for these systems. Finally, we discuss more complex network management applications, including recent work on XML-based network management.

SNMPv1 Performance

In view of its widespread use and long history, surprisingly little is actually known about the way in which a network management system is used in practice, though it is generally assumed that a regular series of monitoring activities generates a fairly fixed, regular sequence of request–response exchanges. Transactions of this nature are generally referred to as a "health check" with a set of network parameters retrieved regularly, determining a component's overall health. For example, to monitor the error rate of a particular network device, we would need to retrieve counters relating to the current number of data packets received, and of those received with errors. We would then wait for a period of time, possibly a few minutes, and repeat the operation, calculating the change ("delta") value and hence the rate. It is necessary to repeat these actions because SNMP deals only in current value or snapshot counters, and the counters are zeroed at some arbitrary point in history, hence the need for a rate calculation. In addition to this regular sequence of activity, there is likely to be a different pattern of manager activity created by a response to a security or fault alert, where the requirement is to diagnose and resolve the problem as quickly as possible.

Typically, a single request–response transaction (a basic SNMP interaction) generates approximately 100 bytes in each direction. General "health check" applications, where maybe fewer than 10 variables are required and the repeat rate is of the order of minutes, have negligible impact, though this increases as numbers of devices to be polled, and/or polling rates, increase (Gavalas, Ghanbari, O'Mahony, & Greenwood, 2000; Pattinson, 2001). This increase in the volume of data delivered to a single management platform limits the number of devices which can be managed in this way. Increasing both volume and frequency of data to five times "normal" levels affected other application performance, while delays in traversing slower links (point-to-point connections) have significant impact (response times increase from 1/100th sec to 1 sec), especially with large data sets (Pattinson, 2001).

Measures also show the profile of traffic generated by network managers responding to fault situations (Donelan, Pattinson, Palmer-Brown, & Lee, 2004). Unsurprisingly, this is of higher, shorter duration, as the network manager collects information necessary to identify and diagnose the fault, and then commands appropriate repairs. Our simulation results revealed that in an otherwise healthy network, it was difficult to generate enough SNMP data of this type to have a measurable impact on overall network loading, though it is recognised that this might change where there is network congestion.

SNMP Extensions

Almost from its introduction, concerns were raised about the performance of SNMPv1, in particular its ability to deliver large volumes of data. This relates particularly to traversal of a tree or table of data. For example, applications which require information about a particular device's routing table would expect to retrieve all, or most of, that table. The mechanism ("tree walk") is simple, but its naïve form creates many request–response pairs, data retrieval overheads are high, and the delay involved can mean the table's content changes between the start and end of retrieval. Therefore, modifications have been suggested, including retrieval of multiple data items (retrieving more than one column of data at once) (Rose, McCloghrie, & Davin, 1990); the get bulk operator (Rose, 2004); and different sequences of table traversal (Breitgand, Raz, & Shavitt, 2002). Some of these mechanisms use existing SNMP specifications, others require modification and deployment in existing networks is more problematic. In particular, the last mentioned creates an entirely new SNMP operator called "get previous," which traverses the tree in reverse order to other operators.

Published results from experiments with these modifications generally show improved retrieval time and reduced data transfer overheads. Rose's (1994) multiple retrievals gave a sixfold reduction in retrieval time for large tables, while using the *get bulk* operator produces an order of magnitude improvement over this; and the *get previous* operation offers two orders of magnitude increase in speed and two to three orders of magnitude decrease in bandwidth over naïve tree traversal (Breitgand et al., 2002). However, in all these cases, the data transfer remains concentrated; all data are passed to the network manager for further processing. As the network grows, this becomes unsustainable, leading to the development of so-called "delegated management" support, where multiple managers control subsets of the network, coordinated by a Manager of Managers (MoM).

The need to react and respond to network problems also generates data transfer requirements. Network managers in such situations respond by collecting as much data as possible (often in excess of that needed) thereby increasing network loading (Donelan et al., 2004). Also detecting intrusion attacks needs a variety of data from a number of different devices and. particularly importantly, it is required quickly so that a defence against the attack can be mounted before the full damage is inflicted (Pattinson & Hajdarevic, 2004). As network size and complexity increase, data collection at a single point becomes unsustainable. Delegation of management defers, rather than addresses, the onset of the problem.

Mobile Agents

Rather than taking data to managers, management functionality can traverse the network, analysing data and making decisions as it goes. Proponents of mobile agents (MAs) claim significant savings in bandwidth and improved responsiveness. Performance analysis (Huang, 2003) indicates:

SNMP generates more transactions than MAs, although MA "transactions" typically carry more payload than SNMP ones. In LAN environments, MAs generate more data (per polling period) than SNMP agents. MAs outperform SNMP agents in traffic efficiency when the initial MA sent out by the management station is >1000 bytes and the size of the domain is small (>50 devices).

In WAN/LAN environments, MAs generate less network traffic than SNMP-agents, because with the former, only initial transfers from, and last returns to, the management station traverse the WAN, therefore only two WAN propagation delays (typically high) occur in each polling period. Conversely, in the SNMP-agent paradigm, every SNMP PDU travels across the WAN, thus incurring two WAN propagation delays (for the request and the reply PDU).

XML vs. SNMP Performance

Some of the most influential figures in network management development indicated that the future of network management is XML-based, and further development of SNMP is unlikely (Pras, Schönwälder, & Festor, 2004). This "possible paradigm shift" (Pras et al., 2004) means that the future network management applications will be significantly more complex than those using the very much simpler constructs of the three SNMP versions. Results (Pras et al., 2004) show that SNMP requires lower bandwidth and CPU resources (although data compression changes this, XML's bandwidth is reduced, while CPU utilisation increases); results for memory usage are inconclusive, and round trip delay is comparable. These initial results, showing higher resource requirements, are expected, but importantly extra resource demand is not seen as a block to adopting XML. A similar "paradigm shift" in processing power and bandwidth availability means the benefits gained from a more complex set of operations outweigh significantly increased network management resource cost. Historically, limiting resource utilisation has been important. The development of high-capacity network devices and increased processing power have diminished this concern, at least for wired network devices. It remains to be seen whether mobile networks and battery-powered devices with more restricted processing and channel capacities are also able to support such network management operations. The current interest in power-saving (energy efficient) network management devices might also impact on this.

CONCLUSION

We are at a change point in network management. The current approach characterised by SNMP is rooted in a desire for simplicity, resulting in design decisions which minimise resource consumption. This objective has historically been the primary criterion against which alternative designs and new methods are judged, and any increased resource utilisation has had to be justified by improvements in service. We have shown that in most cases, these desirable criteria have been met by the current generation of network management protocols. An XML-based future for network management may result in a situation where improved service overtakes minimal performance cost as an acceptance criterion. Of course, the large installed SNMP base means that SNMP-based network monitoring is likely to be a feature for some time to come, but change is definitely in the air.

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KEY TERMS

Centralized/Distributed Management: In small-scale networks, it is possible to create a centralized network management platform, to which all management data is delivered, at which all decisions are taken, and from which all management commands are issued. There are clearly limitations to the size of the network which can be controlled in this manner, limits being created by the bottlenecks of transfer and processing of data at a single location.

Management Agent: A software process able to support some or all of the network management activity required on a networked device. Agents are able to access and, where appropriate, modify data on the devices themselves. Agents are of two major flavors: static agents, which reside on the managed device and respond to management requests; and mobile agents, which are able to transfer between devices, collecting data, making decisions, and affecting device behavior as they move.

MIB: The Management Information Base is a virtual repository of network management data, conceptually located on the devices managed. Software called a management agent possesses the knowledge to extract real data necessary to populate the MIB, whether by direct retrieval of a specific data item or by some processing activity. SNMP requests and responses use MIB names to identify their data.

Network Management: The process of controlling a computer network to ensure it delivers an appropriate service to its users. This term also refers to the software and other equipment used to support this activity. Much of the information required by a network manager is located in the devices which make up the network, in particular, monitoring stations; and producing a complete understanding of the network behavior requires information from different locations, hence either the decision maker must fetch the data, or the decision maker must travel to the location(s) of the data.

Power-Saving Network Management: A growing awareness that networked devices are a significant power drain, even when inactive. The traditional network management processes (device polling, health checks, fault and intrusion detection by anomaly) are predicated on the requirement that networked devices are able and ready to report their status (and to monitor the status of neighbors) on a regular basis, and where a lack of response is taken as an indication of potential device or connection failure. Therefore, networked devices typically remained powered on so that they can respond to checks on a regular basis.

SNMP: The Simple Network Management Protocol is an IETF communications protocol designed to support the function of network management. In its most basic form, it provides support for data retrieval, for modifying data in controlled devices, and for generating alerts. Extensions allow communication between network managers. The original SNMP, now called SNMP version 1 (SNMPv1) is a simple client-server protocol, with no in-built security; successive enhancements brought about SNMPv2, which included more efficient methods for handling larger volumes of data, and SNMPv3, with in-built authentication, encryption, and other security features.

XML-Based Network Management: A proposal to use the Extended Markup Language (XML) to support Web-based access to network management facilities in place of an SNMP-based mechanism. This is expected to have the advantage of making use of universally available Web support software, so removing the need for explicit SNMP protocols, therefore enabling the network management toolset to be richer and more easily provided. A possible disadvantage is the extra load on the network created by this enhanced functionality.

A New Algorithm for Minimizing Tree Pattern Queries

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INTRODUCTION

XML employs a tree-structured model for representing data. Queries in XML query languages, for example, XPath (World Wide Web Consortium, 1999), XQuery (World Wide Web Consortium, 2001), XML-QL (Deutch, Fernandex, Florescu, Levy, & Suciu, 1999), and Quilt (Chamberlin, Clark, Florescu, & Stefanescu 1999; Chamberlin, Robie, & Florescu, 2000), typically specify patterns of selection predicates on multiple elements that have some specified tree structured relationships. For instance, the following XPath expression:

a[*b*[*c* and //*d*]]/*b*[*c* and *e*//*d*]

asks for any node of type *b* that is a child of some node of type *a*. In addition, the *b*-node is the parent of some *c*-node and some *e*-node, as well as an ancestor of some *d*-node. In general, such an expression can be represented by a tree structure as shown in Figure 1(a).

In such a tree pattern, the nodes are types from $\Sigma \cup \{*\}$ (* is a wildcard, matching any node type), and edges are *parent-child* or *ancestor-descendant* relationships. Among all the nodes of a query *Q*, one is designated as the output node, denoted by *output*(*Q*), corresponding to the output of the query.

In the following discussion, we use $\tau(v)$ to denote the type of node *v*. A parent-child edge is referred to as a *c*-edge and a *c*-edge from node *v* to node *u* is denoted by $v \rightarrow u$ in the text. Also, *u* is called a *c-child* of *v*. An ancestor-descendant edge is referred to as a *d*-edge and a *d*-edge is denoted by $v \Rightarrow u$ in the text. *u* is called a *d-child* of *v*. The output node is indicated by "-" in the figures.

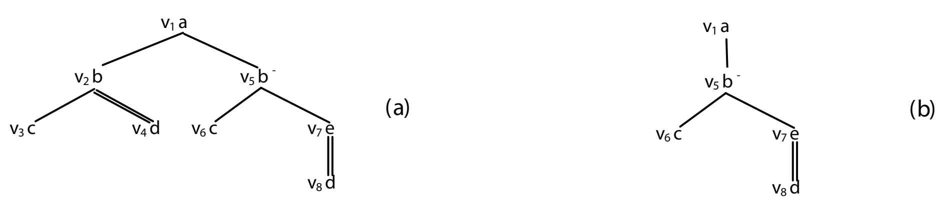
In any DAG (*directed acyclic graph*), a node *u* is said to be a descendant of a node *v* if there exists a path (sequence of edges) from *v* to *u*. In the case of a TPQ, this path could consist of any sequence of *c*-edges and/or *d*-edges.

In terms of Ramanen (1999), an embedding of a tree pattern query (TPQ) *Q* into an XML document *T* is a mapping *f*: $Q \rightarrow T$, from the nodes of *Q* to the nodes of *T*, which satisfies the following conditions:

i. Preserve node type: For each $v \in Q$, *v* and *f*(*v*) are of the same type.
ii. Preserve *c*/*d*-child relationships: If $v \rightarrow u$ in *Q*, then *f*(*u*) is a child of *f*(*v*) in *T*; if $v \Rightarrow u$ in *Q*, then *f*(*u*) is a descendant of *f*(*v*) in *T*.

Any document *T*, in which *Q* can be embedded, is said to contain *Q* and considered to be an answer. An embedding of *Q* in *T* with *root*(*Q*) = *root*(*T*) is called a *root preserving embedding*. According to the above definition, more than one node (of the same type) in *Q* could be mapped to the same node in *T*. In general, the efficiency of finding the result of a query on a given input database depends on the size of the query. Therefore, it is important to minimize the query before attempting to compute the result of the query. In this article, we propose a new algorithm for this task, which

Figure 1. A query tree



needs O(|Q|^2) time and O(|Q|·$leaf_Q$) space, where $leaf_Q$ represents the number of the leaf nodes of Q.

BACKGROUND

In this section, we define the minimization of TPQs and review the related work.

Minimization of TPQs

As an example of TPQ minimization, consider the query shown in Figure 1(a) once again. In this TPQ, the subtree rooted at v_2 is made redundant by the subtree rooted at v_5. Therefore, the TPQ is equivalent to the one shown in Figure 1(b), which is also minimal in the absence of integrity constraints (ICs). In Figure 1(a), if v_2 is the output node (instead of v_5), the TPQ is considered to be minimal in the absence of ICs since if we reduce this TPQ as above, we will not have an output node in the reduced version.

In addition, as pointed out by Amer-Yahia, Cho, Laksmanan, and Srivastava (2001), some ICs may exist in an input database, which may make some branches of a TPQ Q redundant. Therefore, a further reduction is possible. In Amer-Yahia et al. (2001), three kinds of ICs are considered:

1. Required child: Every database node of type τ has a child of type τ', denoted by $\tau \rightarrow \tau$'.
2. Required descendant: Every database node of type τ has a descendant of type τ', denoted by $\tau \Rightarrow \tau$'.
3. Suptype: Every database node of τ is also of type τ', denoted by $\tau \leq \tau$'. For example, we always have "graduate student" ≤ "student." Trivially, $\tau \leq \tau$ for all types τ.

To see how to reduce a TPQ by using ICs, let us have a look at Figure 1(b). If $b \rightarrow c$ is known to hold in the input database, the tree shown in this figure can be reduced to the tree shown in Figure 2(a). If $e \Rightarrow d$ holds besides $b \rightarrow c$, it can further be reduced to the tree shown in Figure 2(b).

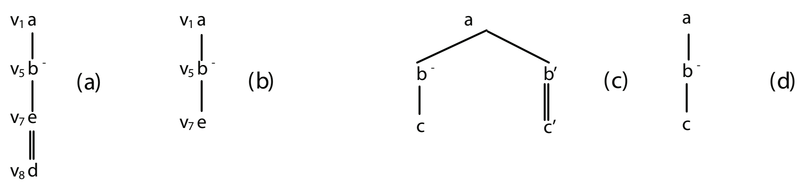
In some cases, in the presence of subtype constraints, a query tree may also be reduced. For example, in the presence of b' ≤ b and c' ≤ c, the tree shown in Figure 2(c) can be reduced to the tree shown in Figure 2(d).

Related Work

The query reduction shown above is closely related to the conjunctive query minimization: a problem that is in general NP-complete for classical relational databases. In the case of TPQs, the problem is treatable in polynomial time in some cases. In Amer-Yahia et al. (2001), the authors pointed out that the tree pattern query is essentially a special kind of conjunctive queries on a tree-structured domain, and presented an O(n^4) algorithm for minimizing TPQs in the absence of integrity constrains. In Florescu, Levy, and Suciu (1998), they showed that containment of conjunctive queries with regular path expressions over semistructured data is decidable (Garey & Johnson, 1979). Techniques like predicate elimination and join minimization are used. However, such kinds of optimization are based on algebraic rewritings, which often generate exponential search spaces and results in problems that cannot be solved in polynomial time.

The minimization of XPath queries in a tree structure database is a harder problem than TPQs. It was first studied in Flesca, Furfaro, and Masciari (2003). In that paper, Flesca et al. address the problem of minimizing XPath queries for limited fragments of XPath, containing only the child, the descendent, the branch, and the wildcard operators.* In their work, they proved

Figure 2. Query tree reduction



the *global minimality* property: a minimum tree pattern equivalent to a given tree pattern *p* can be found among the subpatterns of *p*, and thus can be obtained by pruning "redundant" branches from *p*. Based on such an observation, they designed an algorithm for the tree pattern minimization which works, in general cases, in time exponential w.r.t. the size of input tree patterns. They also characterized the complexity of the minimization problem, showing that given a tree pattern *p* in an XPath fragment and a positive integer *k*, the problem of testing if minimize(p) > k is NP-complete.

Discovering extreme markup language (XML) semantic constraints plays an important role in TPQ minimization and has recently received increasing attention in the research community. In particular, Lee and Chu (2000) showed a variety of semantic constraints hidden implicitly or explicitly from the DTD of an XML database, and proposed two algorithms on discovering and rewriting the semantic constraints in relational database notation. Yu and Popa (2004) studied the problem of constraint-based XML query rewriting for the purpose of data integration. Two novel algorithms, *basic query rewrite* and *query resolution*, have been designed to implement the semantic constraints. More concretely, the basic query rewriting algorithm first reformulates input queries based on containment mapping in terms of the source DTD (no constraint considered). The query resolution algorithm then generates additional rewritings by incorporating XML semantic constraints.

Query minimization in the presence of XML constraints has also been studied by several authors. Calvanese, DeGiacomo, and Lenzerini (1998) studied the problem of conjunctive query containment in the presence of a special class of inclusion dependencies and established some decidability/indecidability results. In addition, Wood (2001, 2003) studied a special class of XPath queries that he called *simple XPath queries*. A simple XPath query is a tree pattern query without descendant child (nodes), but with a flexibility that allows a wildcard, standing for any type of nodes. Wood showed that, in the absence of constraints, the minimal query equivalent to a simple XPath query can be found in polynomial time. Miklau and Suciu (2002) explored the problem in a different way, showing that the minimization of TPQs that contain both child and descendant nodes as well as nodes labeled * is a co-NP complete problem.

As a simplified version of general constraint dependent minimization, the minimization of TPQs was studied by Amer-Yahia et al. (2001). They proposed an O(n^6) time to minimize a TPQ in the presence of three kinds of integrity constraints shown above. Ramanen (2000) tried to improve Amer-Yahia's algorithm and proposed an O(n^2) algorithm for minimizing queries in the absence of integrity constraints, and an O(n^4) algorithm for minimizing queries in the presence of the above three kinds of integrity constraints. Ramanen's algorithm needs O(n^2) space.

Finally, there is a lot of research on the XML query evaluation, such as the methods based on tree paths (Wang & Meng, 2005; Wang, Park, Fan, & Yu, 2003), twig joins (Bruno, Koudas, & Srivastava, 2002; Chen, Lu, & Ling, 2005; Fontoura, Josifovski, Shekita, & Yang, 2005; Jiang, Wang, Lu, & Yu, 2003; Jiang, Wang, & Lu, 2004), and labeled trees (Lakshmanan, Ramesh, Wang, & Zhao, 2004), as well as the method based on parse trees (Gottlob, Koch, & Pichler, 2005). All these methods, however, cannot be utilized for TPQ minimization.

ALGORITHM DESCRIPTION

In this section, we discuss our algorithm for query minimization according to the definition given in Section 1. The main idea of this algorithm is to search both *T* and *Q* bottom-up and checking the subtree embedding by generating dynamic data structures. In the process, a tree labeling technique is used to facilitate the recognition of nodes' relationships. Therefore, in the following, we will first show the tree labeling in 3.1. Then, in 3.2, we discuss the main algorithm. In 3.3, we prove the correctness of the algorithm and analyze its computational complexities.

TREE LABELING

Before we give our main algorithm, we first restate how to label a tree to speed up the recognition of the relationships among the nodes of trees. Consider a tree *T*. By traversing *T* in *preorder*, each node *v* will obtain a number (it can be an integer or a real number) *pre*(*v*) to record the order in which the nodes of the tree are visited. In a similar way, by traversing *T* in *postorder*, each node *v* will get another number *post*(*v*). These two numbers can be used to characterize the ancestor-descendant relationships as follows.

Proposition 1. Let *v* and *v*’ be two nodes of a tree *T*. Then, *v*’ is a descendant of *v* if *pre*(*v’*) > *pre*(*v*) and *post*(*v’*) < *post*(*v*).

Proof. See Exercise 2.3.2-20 in Knuth (1969).

If *v*’ is a descendant of *v*, then we know that *pre*(*v’*) > *pre*(*v*) according to the preorder search. Now we assume that *post*(*v’*) > *post*(*v*). Then, according to the postorder search, either *v’* is in some subtree on the right side of *v*, or *v* is in the subtree rooted at *v*’, which contradicts the fact that *v*’ is a descendant of *v*. Therefore, *post*(*v*’) must be less than *post*(*v*). The following example helps for illustration.

Example 1. See the pairs associated with the nodes of the tree shown in Figure 3. The first element of each pair is the preorder number of the corresponding node and the second is its postorder number. With such labels, the ancestor-descendant relationships can be easily checked. For instance, by checking the label associated with v_2 against the label for v_6, we see that v_2 is an ancestor of v_6 in terms of Proposition 1. Note that v_2’s label is (2, 6) and v_6’s label is (6, 3), and we have 2 < 6 and 6 > 3. We also see that since the pairs associated with v_8 and v_5 do not satisfy the condition given in Proposition 1, v_8 must not be an ancestor of v_5 and *vice versa*.

Definition 1. (*label pair subsumption*) Let (*p*, *q*) and (*p*’, *q*’) be two pairs associated with nodes *u* and *v*. We say that (*p*, *q*) is subsumed by (*p*’, *q*’), denoted (*p*, *q*) (*p*’, *q*’), if *p* > *p*’ and *q* < *q*’. Then, *u* is a descendant of *v* if (*p*, *q*) is subsumed by (*p*’, *q*’). In the following, we also use *T*[*v*] to represent a subtree rooted at *v* in *T*.

ALGORITHM FOR QUERY MINIMIZATION

Now we discuss our algorithm for twig pattern matching. During the process, the query tree *Q* is searched bottom-up. That is, the nodes in *Q* will be accessed along their postorder numbers. Therefore, for convenience, we refer to the nodes in *Q* by their postorder numbers, instead of their node names. In each step, we will check each node *j* in *Q* against all the other nodes *i*. In order to know whether *Q*[*i*] can be embedded into *T*[*j*], we will check whether the following two conditions are satisfied:

1. label(*j*) = label(*i*).
2. Let i_1, ..., i_k be the child nodes of *i*. For each i_a (*a* = 1, ..., *k*), if (*i*, i_a) is a *c*-edge, there exists a child node j_b of *j* such that *Q*[j_b] contains *Q*[i_a]; if (*i*, i_a) is a *d*-edge, there is a descendent *j’* of *j* such that *Q*[*j’*] contains *Q*[i_a].

To facilitate this process, we will associate each *j* in *Q* with a set of nodes: {i_1, ..., i_j} such that for each $i_a \in$ {i_1, ..., i_j} *Q*[i_a] can be root-preservingly embedded into *Q*[*j*]. This set is denoted as *M*(*j*). In addition, each *i* in *Q* is also associated with a value β(*i*), defined as:

i. Initially, β(*i*) is set to ϕ.
ii. During the computation process, β(*i*) is dynamically changed. Concretely, each time we meet a node *j* in *Q*, if *i* appears in *M*(j_b) for some child node j_b of *j*, then β(*i*) is changed to *j*.

In terms of above discussion, we give the algorithm in Algorithm 1.

In the above algorithm, each time we meet a *j* in *Q*, we will establish the new β values for all those nodes, which appear in M(j_1), ..., M(j_k), where j_1, ..., j_k represent the child nodes of *j* (see lines 1-4). In addition, for any *i’* in M(j_l)’s (*l* = 1, ..., *k*), it will be marked to be removable if it is neither a leaf node nor an output node. Then, all M(j_l)’s (*l* = 1, ..., *k*) are removed (see line 5). In a next step, we will check *j* against all the nodes *i* in *Q* (see lines 6-13). If *i* is not subsumed by *j* and label(*i*) = label(*j*), we will check β(i_1), ..., β(i_g), where i_1, ..., i_g are the child nodes of *i*. If (*i*, i_l) ($l \in$ {1, ..., *g*}) is a *c*-edge, we need to check whether β(i_l) = *j* (see line 11). If (*i*, i_l) ($l \in$ {1, ..., *g*}) is a *d*-edge, we simply check whether β(i_l) is subsumed by *j* (see line 12). If all the child nodes of *i* survive the above checking, we get a root-preserving embedding of the subtree rooted at *i* into the subtree rooted at *j*. In this case, we will insert *j* into *M*(*j*) (see line 13) and report *j* as one of the answers if *i* is the root of *Q* (see line 12). In line 15, all the subtrees rooted at a marked node will be removed.

Algorithm 1.

```
Algorithm Query-minimization(Q)
Input: query tree Q (with nodes 1, ..., |Q|)
Output: a minimized Q
begin
  for j := 1, ..., |Q| do
    {let j_1, ..., j_k be the children of j;
     for l := 1, ..., k do
       {for each i' ∈ M(j_l) do {β(i') ← j; if i' is neither a leaf nor an output node, mark i' to be removable;}
        remove M(j_l);}
        for i := 1, ..., |Q| do
          if i is no subsumed by j then
            {if label(i) = label(j) then
              {let i_1, ..., i_g be the children of i;
               if for each i_l (l = 1, ..., g) we have
                  (i, i_l) is a c-edge and β(i_l) = j, or
                  (i, i_l) is a d-edge and β(i_l) is subsumed by j;
               then insert i into M(j);}
  }
  remove all the subtrees rooted at a marked node;
end
```

Example 1. Consider the query tree Q shown in Figure 1(a) once again. Before we apply the algorithm to Q, the nodes in Q are first numbered in postorder, as shown in Figure 3.

In the first two steps, we will generate $M(v_3) = \{v_6\}$ and $M(v_4) = \{v_8\}$. In the third step, we first create $\beta(v_6) = v_2$ and $\beta(v_8) = v_2$. In the subsequent searching, we will meet v_5. Since v_5 is not subsumed by v_2 and label(v_2) = label(v_5), we will check all the child nodes of v_5: v_6 and v_7 and find that $\beta(v_6) = v_2$ but $\beta(v_7) \neq v_2$ So $Q[v_5]$ cannot be embedded into $Q[v_2]$. In the fourth and fifth steps, we will generate $M(v_6) = \{v_3\}$ and $M(v_8) = \{v_4\}$.

In the sixth step, we will check v_7 and create $\beta(v_4) = v_7$. Since v_7 does not match any other node, the child nodes will not be checked. In the seventh step, we check v_5. We remark that at this time point we have $M(v_6) = \{v_3\}$ and $M(v_7) = \{\}$. So we will generate $\beta(v_3) = v_5$. Since v_5 is not subsumed by v_5 and label(v_2) = label(v_5), the child nodes of v_2 will be checked as follows:

- v_3 is a *c*-child node v_2. So we check whether $\beta(v_3) = v_5$.
- v_4 is a *d*-child node v_2. So we check whether $\beta(v_4)$ is subsumed by v_5.

Both the checkings are successful. It indicates that $Q[v_5]$ contains $Q[v_2]$. V_2 is neither a leaf node nor an output node. Thus, it will be marked to be removable. In the eighth step, we will meet the root of Q. No further checking will be performed. In the final step, we remove the subtree rooted at the marked node v_2, getting a reduced query tree shown in Figure 1(b).

Correctness and Computational Complexity

In this subsection, we show the correctness of the algorithm given in 3.2 and analyze its computational complexity.

Correctness. *The correctness of the algorithm consists in a very important property of postorder numbering described in the following lemma.*

Lemma 1. Let v_1, v_2, and v_3 be three nodes in a tree with $post(v_1) < post(v_2) < post(v_3)$. If v_1 is a descendent of v_3, then v_2 must also be a descendent of v_3.

Proof. We consider two cases: (1) v_2 is to the right of v_1, and (2) v_2 is an ancestor of v_1. In case (1), we

Figure 3. Postorder numbering

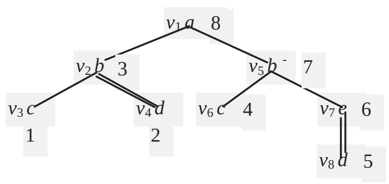
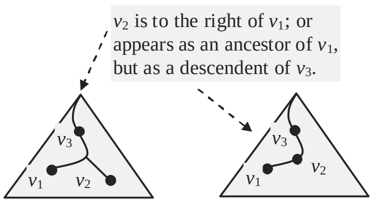


Figure 4. Illustration for Lemma 1



have *post*(v_1) < *post*(v_2). *So we have pre*(v_3) < *pre*(v_1) < *pre*(v_2). This shows that v_2 is a descendent of v_3. In case (2), v_1, v_2, and v_3 are on the same path. Since *post*(v_2) < *post*(v_3), v_2 must be a descendent of v_3. We illustrate Lemma 1 by Figure 4, which is helpful for understanding the proof of Proposition 2 given below.

Proposition 2. Let *Q* be a tree pattern query containing only *d*-edges. Let *v* and *v'* be two nodes in *Q*. Then, *v* appears in *M*(*v'*) if and only if *Q*[*v'*] contains *Q*[*v*].

Proof. *If-part*. A node *v* is inserted into *M*(*v'*) by executing lines 8-13 in Algorithm *Query-minimization* (*Q*). Obviously, for any *v* inserted into *M*(*v'*), we must have *Q*[*v'*] containing *Q*[*v*].

On-if-part. Assume that there exists a *v* in *Q* such that *Q*[*v'*] contains *Q*[*v*] but *v* does not appear in *M*(*v'*). Then, there must be a child node *v''* of *v* such that (1) β(*v''*) = ϕ or (2) β(*v''*) is not subsumed by *v'*. Obviously, case (1) is not possible since *Q*[*v'*] contains *Q*[*v''*] and *v''* must be contained in a subtree rooted at a node *v'''* which is a descendent of *v'*. So β(*v''*) will be changed to a value not equal to ϕ. Now we show that case (2) is not possible, either. First, we note that during the whole process β(*v''*) may be changed several times since it may appear in more than one *M*. Assume that there exist a sequence of nodes v_1, ..., v_k for some $k \geq 1$ with *post*(v_1) < *post*(v_2) <... < *post*(v_k) such that *v''* appears in *M*(v_1), ..., *M*(v_k). Without loss of generality, assume that *v''* = v_i for some $i \in \{1, ..., k\}$ and there exists a *j* such that *post*(v_j) < *post*(*v'*) < *post*(v_{j+1}). Then, at the time point when we check *v*, the actual value of β(*v''*) is the postorder number for v_j's parent, which is equal to *v'* or whose postorder number is smaller than *post*(*v'*). If it is equal to *v'*, then β(*v''*) is subsumed by *v'*, contradicting (2). If *post*(β(*v''*)) is smaller than *post*(*v'*), we have:

post(*v''*) < *post*(β(*v''*)) < *post*(*v'*).

In terms of Lemma 1, the value of (β(*v''*)is a descendent of *v'* and therefore subsumed by *v'*. The above explanation shows that case (2) is impossible. This completes the proof of the proposition.

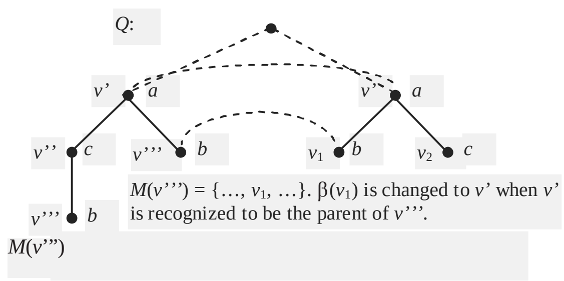
Lemma 1 helps to clarify the on-if part of the above proof. In fact, it reveals an important property of the tree encoding, which enables us to save both space and time. That is, it is not necessary for us to keep all the values of β(*v''*), but only one to check the ancestor-descendent relationship. Due to this property, much space can be saved.

Concerning the correctness of the general case that *Q* contains both *c*-edges and *d*-edges, we have to answer a question: whether any *c*-edge in *Q* is correctly checked. To answer this question, we note that any *c*-edge in *Q* cannot be matched to any path with length larger than 1 in *Q*. That is, it can be matched only to another *c*-edge. It is exactly what is done by the algorithm. See Figure 5 for illustration.

Each time we meet a node *v'*, we will set β values for all those v_js that appear in an *M* associated with some child node of *v'* (see lines 3-4). Then, in lines 8-13, when we check whether *v* can be inserted into *M*(*v'*), any outgoing *c*-edge of *v* is correctly checked. As shown in Figure 5, after the value of β(v_1) is set to be *v'*, *v* is checked and the value of β(v_1) indicates that *v'''* is a child of *v'*. Since (*v'*, *v'''*) is also a *c*-edge, it matches (*v*, v_1). Although the value of β(v_1) is changed from *v''* to *v'* during the process, it does not impact the correctness of *c*-edge checkings which use only the newly set β values that are always the parent of the corresponding nodes. In conjunction with Proposition 2, the above analysis shows the correctness of the algorithm. We have the following proposition.

Proposition 3. Let *Q* be a tree pattern query containing both *c*-edges and *d*-edges. Let *v* and *v'* be two

Figure 5. Illustration for c-edge checking[1]



nodes in Q. Then, v appears in $M(v')$ if and only if $Q[v']$ contains $Q[v]$.

Proof. See the above discussion.

Computational Complexities

The time complexity of the algorithm can be divided into two parts:

1. *The first part is the time spent on generating* β values (see lines 2-5). For each node j in Q, we will access $M(j_i)$ for each child node j_i of j. Therefore, this part of cost is bounded by:

$$O\left(\sum_{j=1}^{|Q|}\sum_{i=1}^{d_j} M(j_i)\right) \le O\left(|Q|\cdot \sum_{j=1}^{|Q|} d_j\right) = O(|Q|^2),$$

   where d_j is the outdegree of j.
2. The second part is the time used for constructing $M(j)$s. For each node j in Q, we need $O(\sum_{i=1}^{|Q|} d_i)$ time to do the task. So this part of cost is bounded by

$$O\left(\sum_{j=1}^{|Q|}\sum_{i=1}^{|Q|} d_i\right) \le O\left(\sum_{j=1}^{|Q|} |Q|\right) = O(|Q|^2).$$

The space overhead of the algorithm is easy to analyze. During the processing, each j in Q will be associated with a $M(j)$. But $M(j)$ will be removed later once j's parent is encountered and for each $i \in M(j)$ its β value is changed. Therefore, the total space is bounded by:

$$O(leaf_Q \cdot |Q| + |Q|),$$

where $leaf_Q$ represents the number of the leaf nodes of Q. It is because at any time point for any two nodes on the same path in T only one is associated with a M.

FUTURE TRENDS

As shown in the second section, a query tree may be further reduced in the presence of integration constraints. The existing method (Ramanen, 2000) needs to augment a tree using the following rules:

1. If $\tau \rightarrow \tau'$, then add $\tau \Rightarrow \tau'$.
2. If $\tau \Rightarrow \tau'$ and $\tau' \Rightarrow \tau''$, then add $\tau \Rightarrow \tau''$.
3. If $\tau \le \tau'$ and $\tau' \le \tau''$, then add $\tau \le \tau''$.
4. If $\tau \le \tau'$ and $\tau' \rightarrow \tau''$, then add $\tau \rightarrow \tau''$.
5. If $\tau \le \tau'$ and $\tau' \Rightarrow \tau''$, then add $\tau \Rightarrow \tau''$.
6. If $\tau \rightarrow \tau'$ and $\tau' \le \tau''$, then add $\tau \rightarrow \tau''$.
7. If $\tau \Rightarrow \tau'$ and $\tau' \le \tau''$, then add $\tau \Rightarrow \tau''$.

Although the query minimization algorithm needs only $O(n^2)$ time, the query augmentation process runs in $O(n^4)$ time. Thus, as a future work, we will concentrate on how to reduce the time complexity of this operation to speed up the whole query evaluation process.

CONCLUSION

In this article, a new algorithm for the minimization of tree pattern queries has been discussed. The algorithm runs in $O(n^2)$ time and $(n \cdot leaf_Q)$ space, where $leaf_Q$ represents the number of the leaf nodes of Q. In comparison with the existing methods, our method maintains a quite simple structure and uses much less space. Although our algorithm has the same worst-case time complexity as Ramanen's, it works in less time on average. It is because during the process, a much smaller data structure is produced. In the presence of three kinds of integrity constrains (required child, required descendant, and subtype), Ramanen's method can be incorporated into our algorithm to produce a $O(n^4)$ time solution to the problem.

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KEY TERMS

Document Database: A database designed for managing and manipulating XML documents or even more generic SGML documents.

Integrity Constraints: A set of rules that the data in an XML document database satisfy, such as required child, required descendent, and type-subtype relationship.

Tree Embedding: A mapping that maps a tree pattern query into an XML document by which the node types, and parent-child and ancestor-descendent relationships are preserved.

Tree Labeling: A method to assign the nodes of a tree a number or a bit string, which reflects some relationshiops among the nodes and can be used to facilitate computation.

Tree Pattern Minimization: A process to recognize similar parts in a tree pattern query. All the similar parts will be removed to reduce the size of the query.

Tree Pattern Query: Queries represented as a tree structure, where the nodes are types from $\sum \cup \{*\}$ (* is a wildcard, matching any node type), and edges are *parent-child* or *ancestor-descendant* relationships. Among all the nodes of a query *Q*, one is designated as the output node, denoted by *output*(*Q*), corresponding to the output of the query.

XML Document: A document consisting of an (optional) XML declaration, followed by either an (optional) DTD or XML schema, and then followed by a document element.

A New Algorithm for Subset Matching Problem Based on Set-String Transformation

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INTRODUCTION

In computer engineering, a number of programming tasks involve a special problem, the so-called *tree matching* problem (Cole & Hariharan, 1997), as a crucial step, such as the design of interpreters for nonprocedural programming languages, automatic implementation of abstract data types, code optimization in compilers, symbolic computation, context searching in structure editors and automatic theorem proving. Recently, it has been shown that this problem can be transformed in linear time to another problem, the so called *subset matching* problem (Cole & Hariharan, 2002, 2003), which is to find all occurrences of a pattern string p of length m in a text string t of length n, where each pattern and text position is a set of characters drawn from some alphabet Σ. The pattern is said to occur at text position i if the set $p[j]$ is a subset of the set $t[i + j - 1]$, for all j ($1 \leq j \leq m$). This is a generalization of the ordinary string matching and is of interest since an efficient algorithm for this problem implies an efficient solution to the tree matching problem. In addition, as shown in (Indyk, 1997), this problem can also be used to solve general string matching and counting matching (Muthukrishan, 1997; Muthukrishan & Palem, 1994), and enables us to design efficient algorithms for several geometric pattern matching problems. In this article, we propose a new algorithm on this issue, which needs only $O(n + m)$ time in the case that the size of Σ is small and $O(n + m \cdot n^{0.5})$ time on average in general cases.

BACKGROUND

The subset matching problem was defined in Cole and Hariharan (1997) and shown also in Cole and Hariharan (1997) and its improved version (Cole and Hariharan, 2003) that the well-known tree pattern matching problem can be linearly reduced to this problem. Formally, the text t is a string of length n and the pattern p is a string of length m. Each text position $t[i]$ and each pattern position $p[j]$ is a set of characters (not a single character), taken from a certain alphabet Σ. Strings, in which each location is a set of characters, will be called *set-strings* to distinguish them from ordinary strings. Pattern p is said to match text t at position i if $p[j] \subseteq t[i + j - 1]$, for all j ($1 \leq j \leq m$). As an example, consider the set-strings t and p shown in Figure 1.

Figure 1(a) shows a matching case, by which we have $p[j] \subseteq t[i + j - 1]$ for $i = 1$, and $j = 1, 2, 3$, while Figure 1(b) illustrates an unmatching case since for $i = 2$ we have $p[2] \not\subset t[i + 2 - 1]$.

Until now, the best way for solving subset matching is based on the construction of superimposed codes, or bit strings (see Chen, 2006; Faloutsos, 1995), for the characters in Σ and the convolution operation of vectors (Aho, Hopcroft, & Ullman, 1974). The superimposed codes are generated in such a way that no bit string (for a character) is contained in a Boolean sum of l other bit strings, where l is the largest size of the sets in both t and p. As indicated in Cole and Hariharan (2002), such superimposed codes can be generated in $O(n\log^2 m)$ time. In addition, by decomposing a subset matching into several smaller problems (see Cole & Hariharan, 1997), the convolution operation can also be done in $O(n\log^2 m)$ time by using Fourier transformation (Aho et al., 1974) (if the cardinality of Σ is bounded by a constant). Therefore, the algorithm discussed in Cole and Hariharan (2002) needs only $O(n\log^2 m)$ time.

In this article, we explore a quite different way to solve this problem. The main idea of our algorithm is to transform a subset matching problem into another subset matching problem by constructing a trie over the text string. In the new subset matching problem, t is reduced to a different string t', in which each position is an integer (instead of a set of characters); and p is changed to another string p', in which each position remains a set (of integers). This transformation gives us a chance to use the existing technique for string

Figure 1. Example of subset match

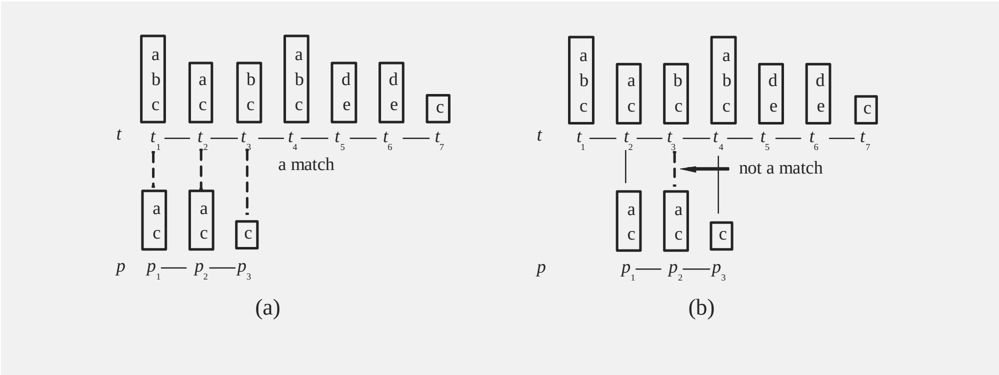


Figure 2. A 0-1 matrix for a text string

$$
\begin{array}{c}
\\ a \\ b \\ c \\ d \\ e
\end{array}
\begin{array}{c}
\begin{array}{ccccccc} 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{array} \\
\left[\begin{array}{ccccccc}
1 & 1 & 0 & 1 & 0 & 0 & 0 \\
1 & 0 & 1 & 1 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 1 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 & 1 & 0
\end{array}\right]
\end{array}
$$

matching to solve the problem. Concretely, we will generate a suffix tree over t' and search the suffix tree against p' in a way similar to the traditional methods. If the size of the alphabet is small, our method needs only $O(n + m)$ time. But in general cases, it needs $O(n + m \cdot n^{0.5})$ time on average.

The remainder of the article is organized as follows. In the second section, we discuss our algorithm, which is designed based on a transformation of subset matching problems. In the third section, we analyze the average time of a trie searching, which shows the average cost of our method. Finally, the fourth section is a short conclusion.

ALGORITHM DESCRIPTION

Assume that $\Sigma = \{1, ..., k\}$. We construct a 0-1 matrix $T = (a_{ij})$ for $t = t_1t_2 \ldots t_n$ such that $a_{ij} = 1$ if $i \in t_j$ and $a_{ij} = 0$ if $i \notin t_j$ (see Figure 2 for illustration). In the same way, we construct another 0-1 matrix $P = (b_{ij})$ for $p = p_1p_2 \ldots p_m$.

Then, each column in T (P) can be considered as a bit string representing a set in t (in p). (In the following discussion, we use $b(t_i)$ ($b(p_j)$) to denote the bit string for t_i (p_j).)

In a next step, we construct a (compact) trie over all $b(t_i)$'s, denoted by *trie*(T), as illustrated in Figure 3(a).

In this trie, for each node, its left outgoing edge is labeled with a string beginning with 0 and its right outgoing edge is labeled with a string beginning with 1; and each path from the root to a leaf node represents a bit string that is different from the others. In addition, each leaf node v in *trie*(T) is associated with a set containing all those t_i's that have the same string represented by the path from the root to v. Then, t can be transformed as follows:

- Number all the leaf nodes of the trie from left to right (see Figure 3 for illustration).
- Replace each t_i in t with an integer that numbers the leaf node, with which a set containing t_i is associated.

For example, the text string t shown in Figure 1(a) will be transformed into a string t' as shown in Figure 3(b), in which each position is an integer. For this example, t_1 and t_4 are replaced by 5, t_2 by 4, t_3 by 3, t_5 and t_6 by 1, and t_7 by 2.

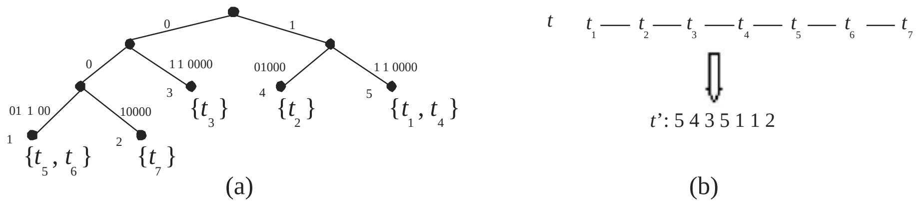
In order to find all the sets in t, which contain a certain p_j, we will search *trie*(T) against $b(p_j)$ as below.

(i) Denote the ith position in $b(p_j)$ by $b(p_j)[i]$.

(ii) Let v (in *trie*(T)) be the node encountered and $b(p_j)[i]$ be the position to be checked. Denote the left and right outgoing edges of v by e_l and e_r, respectively.

- If $b(p_j)[i] = 1$, we will explore the right outgoing edge e_r of v. That is, we will compare the label of e_r, denoted by $l(e_r)$, with the corresponding substring in $b(p_j)$ according to the following criteria: if one bit in $b(p_j)$ is 1, the corresponding bit in $l(e_r)$ must be one; if one bit in $b(p_j)$ is 0,

Figure 3. Illustration for trie and set-string transformation



it does not matter whether the corresponding bit in $l(e_r)$ is 1 or 0. If they match, we move to the right child of v.

- If $b(p_j)[i] = 0$, we will explore both e_l and e_r will be explored.

In fact, this definition just corresponds to the process of checking whether a set is a subset of another.

For example, to find all the t_i's in the text string t shown in Figure 1(a), which match p_1 in p shown in the same figure, we will search the trie against $b(p_1)$ = 1010000. For this, part of the trie will be traversed as illustrated by the heavy lines in Figure 4(a).

This shows that in t there are three sets t_1, t_2, and t_4 containing p_1. But in t', t_1, and t_4 are represented by 5, and t_2 is represented by 4. So we associate {4, 5} with p_1 and replace p_1 in p with {4, 5}. In this way, we will transform p into another string p', in which each position remains a set containing some integers that represent all those sets in t, which contain the corresponding set at the same position in p. (See Figure 4(b) for illustration.) If k (the size of Σ) is small, each set in p' can be represented by a bit string of length 2^k. If i belongs to the set, the ith position is set to 1; otherwise, it is set to 0. Thus, a membership checking needs only O(1) time. If k is not small, we will store a set as an array. Since we always search the trie top-down and from left to right, the array is always sorted ascendingly. Moreover, the size of any set in p' is bounded by $min\{n, 2^k\}$. So the time for a membership checking is bounded by O(k), a constant.

Formally, the above transformation defines two functions:

$$f_t: Set_t \to I,$$

where Set_t is the set of all t_i's in t and $I = \{1, ..., 2^k\}$; and

$$f_p: Set_p \to 2^I,$$

where Set_p is the set of all p_j's in p and 2^I is the set containing all the subsets of I, that is, the power set of I. Obviously, these two functions satisfy the following property.

Lemma 1. Let t_i be a set in t and p_j be a set in p. Assume that $f_t(t_i) = a$ and $f_p(p_j) = b$. Then, we have $t_i \supseteq p_j$ if and only if $a \in b$.

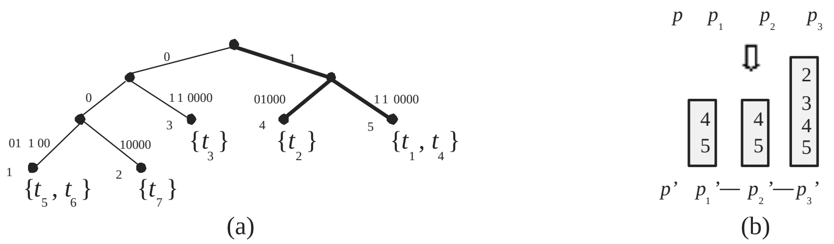
Proof. It can be directly derived from the above definition of the string transformations.

In a next step, we construct a suffix tree over t', the transformed t, using a well-known algorithm such as the algorithms discussed in McCreight (1974) and Ukkonen (1995). It needs only O(n) time. For example, for the string shown in Figure 3(b), we will generate a suffix tree as shown in Figure 5.

In this tree, each internal node v is associated with an integer (denoted as $int(v)$) to indicate the position (in p') to be checked when searching; and each edge is labeled with a substring and all the labels along a path (from the root to a leaf node) form a suffix in t', plus \$, a special symbol, which makes every suffix not a prefix of any other. So a leaf node can be considered as a pointer to a suffix. In order to find all the substrings in t, which match p, we will explore the suffix tree for the transformed string t' against the transformed $p' = p_1'p_2' \ldots p_m'$ as follows.

(i) Search the suffix tree from the root;
(ii) Let v be the node encountered and p_i' be the set to be checked.

Figure 4. Illustration for trie and set-string transformation



Algorithm 1.

Algorithm *Subset-Matching*

begin

1. Let $t = t_1t_2 \dots t_n$ and $p = p_1p_2 \dots p_m$;

2. Transform t to $t' = t_1't_2' \dots t_n'$ and p to $p' = p_2' \dots p_m'$ by using the trie constructed over t;

3. Construct a suffix tree t_{suffix} over t';

4. Search t_{suffix} against p';

4. **for** any $e = (v, u)$ in t_{suffix} with $l(e) = l_1 \dots l_g$, which is checked with $l_g \in p_m'$ **do**

5. {return all the leaf nodes in the subtree rooted at u;}

end

(iii) Let $e_1, \dots, e_q$ be v's outgoing edges. Let $l(e_j) = l_{j_1} \dots l_{j_h}$ (for some h) be the label of e_j ($1 \le j \le l$). Then, for any $e_j = (v_j, u_j)$ ($1 \le j \le q$), if $l_{j_1} \in p'_{i+int(v)-1}$, $l_{j_2} \in p'_{i+int(v)}$..., and $l_{j_h} \in p'_{i+int(v)+h-1}$, the subtree rooted at u_j will be continually explored. Otherwise, the subtree will not be searched anymore. In addition, we notice that the symbol \$ is always ignored when we check the labels associated with the edges in *trie*(T).

In the above process, for any $e = (v, u)$ with $l(e) = l_1 \dots l_g$, if l_g is checked against p_m' with $l_g \in p_m'$, any leaf node in the subtree rooted at u indicates a substring in t, which matches p. Algorithm 1 is the formal description of the whole process.

Example 1. By applying the above algorithm to the problem shown in Figure 1(a), *trie*(T) shown in Figure 3(a) will be first generated and t will be transformed to t' as shown in Figure 3(b). Then, by searching *trie*(T) against each p_i one by one, we will transform p to p' as shown in Figure 4(b). The suffix tree for t' is shown in Figure 5. Finally, we will search the suffix tree against p' as shown by the heavy edges in Figure 6.

For this simple example, only one path in the suffix tree is explored. But multiple paths may be searched in general.

Proposition 1. Let $t = t_1t_2 \dots t_n$ and $p = p_1p_2 \dots p_m$. The algorithm *Subset-Matching* will find all t_i's ($1 \le i \le n - m$) such that $t_{i+1}t_{i+2}\dots t_{i+m-1}$ matches p.

Proof. Let $n_1 \to n_2 \dots \to n_m \to n_{m+1}$ be a path that is visited when searching the trie against p'. Let $l_i = l(n_i, n_{i+1})$ denote the label associated with the edge (n_i, n_{i+1}) ($1 \le i \le m$). Then, we must have $l_i \in p_i'$ ($1 \le i \le m$). In terms of Lemma 1, the substring in t: $f_t^{-1}(l_1) \dots f_t^{-1}(l_m)$ definitely matches $f_p^{-1}(p_1') \dots f_p^{-1}(p_m') = p_1p_2 \dots p_m$. We remark that all the suffixes represented by the leaf nodes in the subtree rooted at n_{m+1} has $l_1 \dots l_m$ as the prefix. So

Figure 5. The suffix tree for t'

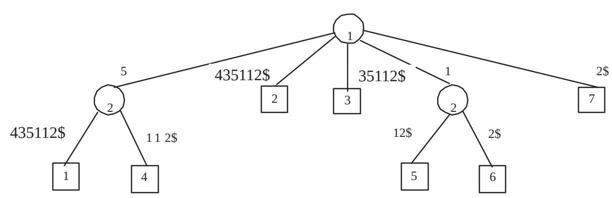
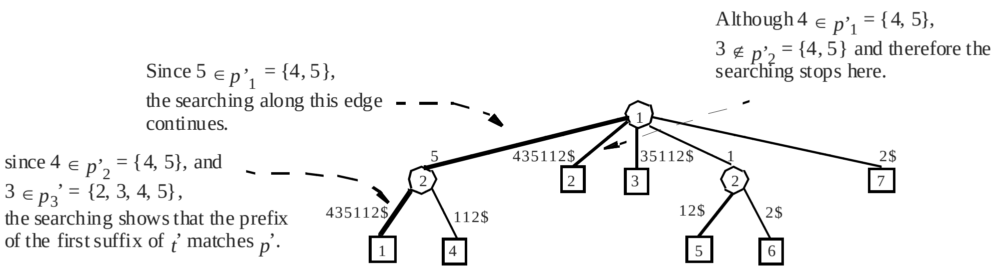


Figure 6. Illustration for suffix tree searching



each of these suffixes corresponds to a substring in t, which matches p.

Concerning the time complexity of the algorithm, we consider two cases: small k and large k, where k is the size of Σ. In the case that k is small, the cost can be analyzed as follows. First, we need $O(n)$ time to construct the trie for t and to generate t'. Then, to produce p' for p, we need $O(C \cdot m)$ time, where C represents the largest cost of searching the trie against a p_i ($1 \le i \le m$). Obviously, C is bounded by $2 \cdot 2^k$. It is because the number of the leaf nodes of the trie is bounded by 2^k and the trie is in fact a binary tree. In addition, a set in p' can be represented as a bit string of length 2^k and the membership checking needs only a constant time. Thus, for both the suffix tree construction and the suffix tree searching, we need $O(n)$ time. So the total time is bounded by $O(n + C \cdot m) = O(n + 2 \cdot 2^k \cdot m) = O(n + m)$.

In the case that k is not small, the trie constructed for t might be large (but bounded by $2 \cdot min\{n, 2^k\}$) and the trie searching becomes a dominant factor of time complexity. In the next section, we will make a probabilistic analysis of this cost, which shows that the time spent on searching a trie of size N is on the order of $O(N^{0.5})$ on average. Since $N \le 2 \cdot min(n, 2^k)$, the average cost of our algorithm is bounded by $O(n + C \cdot m) = O(n + m \cdot n^{0.5})$.

ANALYSIS OF *C*

In order to analyze the average cost of a trie searching, we consider a "worse" case that the trie is not compact; that is, each edge is labeled with a single bit (instead of a bit string), which makes the analysis easier. In Figure 7(a), we show a noncompact trie for a set of bit strings shown in Figure 7(b).

For such a noncompact trie T, the searching of it against a bit string $s = s[1]s[2] \dots .s[k]$ is performed in a similar way to a compact trie, but simpler:

(i) Let v be the node encountered and $s[i]$ be the position to be checked.
(ii) If $s[i] = 1$, we move to the right child of v.
(iii) If $s[i] = 0$, both the right and left child of v will be visited.

In the following, we use $c_s(T)$ to represent the cost of searching T against s. In addition, we use s', s'', s''', ... to designate the patterns obtained by circularly shifting the bits of s to the left by 1, 2, 3, ... positions.

Obviously, if the first bit of s is 0, we have, for the expected cost of a random string s:

$$c_s(T) = 1 + c_{s'}(T_1) + c_{s'}(T_2), \tag{1}$$

where T_1 and T_2 represent the two subtrees of the root of T. See Figure 8 for illustration.

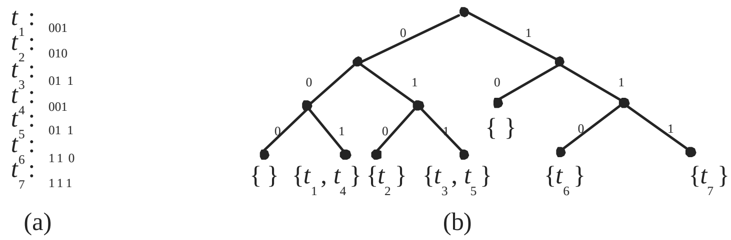
It is because, in this case, the search has to proceed in parallel along the two subtrees with s changing cyclically to s'. If the first bit in s is 1, we have:

$$c_s(T) = 1 + c_{s'}(T_2) \tag{2}$$

since in this case the search proceeds only in T_2.

Given N ($N \ge 2$) random nodes in T, the probability that:

Figure 7. A non-compact trie



$$|T_1| = q,\ |T_2| = N - q \tag{3}$$

can be estimated by the *Bernoulli* probabilities

$$\binom{N}{q}\left(\frac{1}{2}\right)^q\left(\frac{1}{2}\right)^{N-q} = \frac{1}{2^N}\binom{N}{q} \tag{4}$$

Let $c_{s,N}$ denote the expected cost of searching a trie of size N against s. We have the following recurrences:

$$\text{if } s \text{ starts with 0, } c_{s,N} = 1 + \frac{2}{2^N}\sum_q \binom{N}{q} c_{c',q}\ ,\ N \geq 2; \tag{5}$$

$$\text{if } s \text{ starts with 1, } c_{s,N} = 1 + \frac{1}{2^N}\sum_q \binom{N}{q} c_{c',q}\ ,\ N \geq 2. \tag{6}$$

Let $\lambda_i = 1$ if ith bit in s is 1, and $\lambda_i = 2$ if ith bit in s is 0. The above recurrence can be rewritten as follows:

$$c_{s,N} = 1 + \frac{\lambda_1}{2^N}\sum_q \binom{N}{q} c_{c',q} - \delta_{N,0} - \delta_{N,1}, \tag{7}$$

where $\delta_{N,j}$ (j = 0, 1) is equal to 1 if $N = j$; otherwise equal to 0.

Proposition 2. The exponential generating function of the average cost $c_{s,N}$

$$C_s(z) = \sum_{N\geq 0} c_{s,n}\frac{z^N}{N!} \tag{8}$$

satisfies the relation

$$C_s(z) = \lambda_1 e^{z/2} C_{s'}\left(\frac{z}{2}\right) + e^z - 1 - z. \tag{9}$$

Proof. In terms of Equation (7), $C_s(z)$ can be rewritten as:

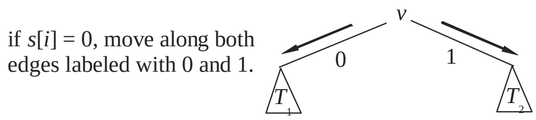
$$\begin{aligned}
C_s(z) &= \sum_{n\geq 0}\left(1 + \lambda_1\left(\tfrac{1}{2}\right)^n \sum_p \binom{n}{p} c_{s',p} - \delta_{n,0} - \delta_{n,1}\right)\frac{z^n}{n!} \\
&= \sum_{n\geq 0}\frac{z^n}{n!} + \sum_p \lambda_1\left(\tfrac{1}{2}\right)^n \sum_{n\geq 0}\binom{n}{p} c_{s',p}\frac{z^n}{n!} - \sum_{n\geq 0}\delta_{n,0}\frac{z_n}{n!} - \\
&\qquad \sum_{n\geq 0}\delta_{n,1}\frac{z_n}{n!} \\
&= e^z + \lambda_1 \sum_p \frac{(z/2)^p}{p!}\sum_{n\geq 0} c_{s',p}\frac{(z/2)^{n-p}}{(n-p)!} - 1 - z \\
&= \lambda_1 e^{z/2} C_{s'}\left(\tfrac{z}{2}\right) + e^z - 1 - z.
\end{aligned} \tag{10}$$

In the same way, we will get $C_{s'}(z)$, $C_{s''}(z)$, ..., and so on. Concretely, we will have the following equations:

$$\begin{aligned}
C_s(z) &= \lambda_1 e^{z/2} C_{s'}\left(\tfrac{z}{2}\right) + e^z - 1 - z, \\
C_{s'}(z) &= \lambda_2 e^{z/2} C_{s''}\left(\tfrac{z}{2}\right) + e^z - 1 - z \\
&\dots\dots \\
C_{s^{(k-1)}}(z) &= \lambda_k e^{z/2} C_s\left(\tfrac{z}{2}\right) + e^z - 1 - z.
\end{aligned} \tag{11}$$

This system can be solved by successive transportation. For instance, when we transport the expression of $C_{s'}(z)$ given by the second equation in (11), we have:

Figure 8. Illustration for signature tree searching



$$C_s(z) = a(z) + \lambda_1 e^{z/2} a\left(\frac{z}{2}\right) + \lambda_1\lambda_2 e^{z/2} e^{z/2^2} C_{s''}\left(\frac{z}{2^2}\right) \quad (12)$$

where $a(z) = e^z - 1 - z$.

In a next step, we transport $C_{s'''}$ into the equation given in (12). This kind of transformation continues until the relation is only on C_s itself. Then, we have:

$$C_s(z) = \lambda_1\lambda_2 \ldots \lambda_k exp\left[z\left(1-\frac{1}{2^m}\right)\right] C_s\left(\frac{z}{2^m}\right) + \sum_{j=0}^{k-1}\lambda_1\lambda_2\cdots\lambda_j exp\left[z\left(1-\frac{1}{2_j}\right)\right]\left(exp\left(\frac{z}{2^j}\right)-1-\frac{z}{2^j}\right)$$

$$= 2^{k-b} exp\left[z\left(1-\frac{1}{2^m}\right)\right] C_s\left(\frac{z}{2^m}\right) + \sum_{j=0}^{k-1}\lambda_1\lambda_2\cdots\lambda_j exp\left[z\left(1-\frac{1}{2_j}\right)\right]\left(exp\left(\frac{z}{2^j}\right)-1-\frac{z}{2^j}\right), \quad (13)$$

where b is the number of 1s in s.

Let $\alpha = 2^{k-b}$, $\beta = 1$ -, l =, and $A(z)$ = and $A(z) = \sum_{j=0}^{k-1}\lambda_1\lambda_2\cdots\lambda_j exp\left[z\left(1-\frac{1}{2_j}\right)\right]\left(exp\left(\frac{z}{2^j}\right)-1-\frac{z}{2^j}\right)$. We have:

$$C_s(z) = \alpha e^{\beta} z C_s(\lambda z) + A(z). \quad (14)$$

This equation can be solved by iteration as discussed above:

$$C_s(z) = \sum_{j=0}^{\infty}\alpha^j exp\left(\beta \frac{1-\lambda^j}{1-\lambda} z\right) A\left(\lambda^j z\right) \quad (15)$$

$$= \sum_{j=0}^{\infty} 2^{j(k-b)} \sum_{h=0}^{k-1}\lambda_1\lambda_2\cdots\lambda_h \left[exp(z) - exp\left(z\left(1-\frac{1}{2^h 2^{mj}}\right)\right)\left(1+\frac{z}{2^h 2^{mj}}\right)\right].$$

Using the *Taylor* formula to expand $exp(z)$ and $exp\left(z\left(1-\frac{1}{2^h 2^{mj}}\right)\right)\left(1+\frac{1}{2^h 2^{mj}}\right)$ in $C_s(z)$ given by the above sum, and then extract the *Taylor* coefficients, we get

$$c_{s,n} = \sum_{h=0}^{k-1}\lambda_1\lambda_2\cdots\lambda_h \sum_{j\geq 0} 2^{j(k-b)} D_{jh}(n) \quad (16)$$

where $D_{00}(n) = 1$ and
for $j > 0$ and $h > 0$,
$$D_{jh}(n) = 1 - (1 - 2^{-kj-h})^n - x2^{-kj-h}(1 - 2^{-kj-h})^{n-1} \quad (17)$$

To estimate $c_{s,n}$, we resort to the complex analysis, which shows that $c_{s,n} \sim n^{1-\frac{b}{k}}$. If $\frac{b}{k} = \frac{1}{2}$, we have:

$$c_{s,n} = O(n^{0.5}). \quad (18)$$

An interested reader is referred to Chen (2006) and Chen and Chen (2006) for a detailed analysis on how to evaluate c_s,N given by Equation (16) by using contour integration of complex variabled functions in great detail. Finally, we notice that $N \leq min\{n, 2^k\}$. So $c_{s,N} = O(N^{0.5}) \leq O(n^{0.5})$. This shows that the average time complexity of Algorithm *Set-Matching* is on the order of $O(n + m\cdot n^{0.5})$.

FUTURE TRENDS

As mentioned earlier, the subset matching has a lot of applications to information processing and retrieval, such as the tree matching problem, general string matching and general counting matching. It also enables us to design efficient algorithms for several geometric pattern matching problems. Especially the idea of transforming a subset matching to another simpler subset matching seems to be useful for a more difficult problem, the so-called *superset-matching with don't care*. The goal of that problem is to search for the occurence of the pattern containing "don't care" symbols and OR-expressions of the form: $s_1 \vee s_2 \vee \ldots \vee s_k$, where s_i's are symbols. In the near future, we will explore in this direction and try to find more efficient algorithms for that problem.

CONCLUSION

In this article, a new algorithm for the subset-matching problem is proposed. The main idea of the algorithm is to represent each set t_i in the text string t as a single integer a and each set p_j in the pattern string p as a set b of integers such that $a \in b$ if and only if $p_j \subseteq t_i$. This is done by constructing a trie structure over t. In this way, we transform the original problem into a different subset matching problem, which can be efficiently solved by generating a suffix tree over the new text string that has an integer at each position. By a probabilistic analysis, together with the contour integration of complex variabled functions, we show that the average time spent on the trie construction is on the order of $O(n + m \cdot n^{1-\frac{b}{k}})$, where n is the length of the text string, m is the length of the pattern string, k is the size of the alphabet, and b is the average number of bits set to 1 in a bit string representing a set in p. If:

$$\frac{b}{k} = \frac{1}{2},$$

the average time complexity of our algorithm is bounded by $O(n + m \cdot n^{0.5})$.

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KEY TERMS

Set-String Transformation: The set-string transformation for a given subset matching is to transform the text set-string t and the pattern set-string p into two different strings t' and p' so that p has matches in t if and only if p' has matches in t'.

String Matching: A string matching problem is to find all the occurrences of a pattern string (a sequence of characters) in a text string (another sequence of characters).

Subset Matching: The *subset matching* problem is to find all occurrences of a pattern string p of length m in a text string t of length n, where each pattern and text position is a set of characters drawn from some alphabet Σ. The pattern is said to occur at text position i if the set $p[j]$ is a subset of the set $t[i + j - 1]$, for all j $(1 \leq j \leq m)$. This is a generalization of the ordinary string matching problem.

Suffix Tree: A suffix tree is a trie over all the suffices of a string.

Tree: A tree is a graph, in which each node may have more one child nodes, but only one parent.

Tree Matching: The tree matching problem is to find all occurrences of a pattern tree P in a target tree T. A pattern tree P matches a target tree T at node v if there exists a one-to-one map from the nodes of P into the nodes of T such that:

(1) the root of P maps to v,
(2) if x maps to y, then x and y have the same label, *i.e.*, $label(x) = label(y)$, and
(3) if x maps to y and x is not a leaf, then the ith child of x maps to the ith child of y. (In particular, the outdegree of y is no less than the outdegree of x.)

Trie: A trie for a set of strings is a type of digit search tree over a finite alphabet Σ. In the trie, each edge represnts a symbol from Σ, and sibling edges must represent distinct symbols. In addition, each path from the root to a leaf node forms a prefix of a string, which differs the string from the others.

A Novel Application of the P2P Technology for Intrusion Detection

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INTRODUCTION

The importance of the network security problems come into prominence by the growth of the Internet. This article presents a new kind of software that uses the network itself to protect the hosts and increase their security. The hosts running this software create an application level network (ALN) over the Internet (Hosszú, 2005). Nodes connected to this ALN check their operating systems' log files to detect intrusion attempts. Information collected this way is then shared over the ALN to increase the security of all peers, which can then make the necessary protection steps, for example, blocking network traffic by their own *firewall*.

Different kinds of security software utilizing the network were also written previously (Snort, 2006). The novelty of Komondor is that its client software entities running in each host create a *peer-to-peer* (P2P) *overlay network* (Czirkos, 2006). Organization is automatic; it requires no user interaction. This network model ensures stability, which is important for quick and reliable communication between nodes. By this build-up, the system remains useful over the unstable network.

THE IMPORTANCE OF THE P2P COMMUNICATIONS

The Internet-based communication technology enabled people to share information with anybody in seconds. This has brought benefits to people spanning many spheres from social services to education (Frasz, 2005). Probably the best example of such extended network of content sharing is the P2P that allows users to download media files off other computers free of charge. Once content enters the Internet, it can be downloaded by an unlimited number of people.

One of the latest steps in the steady advances in P2P technologies is the release of new P2P technologies in 2005 that enable a user community to filter out mislabeled or corrupt files (Goth, 2005). One approach to build a more trustworthy P2P overlay is the application credence (Sirer & Walsh, 2005). It rates a certain network object instead of a given peer node for trustworthiness. The reason is that nodes can be inhabited by various people over time, but the data in the object itself does not change. This system uses a secure and anonymous voting mechanism. Over time, users with similar votes or the legitimacy of a file will dynamically form a kind of community enabling enough correlation of trust. Similarly, a user that systematically answers contrarily will get an equally significant negative weighting; however, an inconsistent voter will have less statistical weight. In such a way, the more users who join credence overlay, the more accurate an overall rating each file will receive.

The trend of the P2P systems is building more resilient services. Centralized solutions are fragile, since a single link breakage in the network can cut access to the whole service. P2P enables higher ability to construct overlays that self-organizes and recovers from failures.

Another interesting and important feature of the development process of the P2P technology is that the most successful projects are open sources such as LimeWire, which is a Gnutella client with rapidly growing popularity (Bildson, 2005). Its business model has two sides. One version is free, however, advertising-supported, and the other is ad-free, but the users must pay for it. LimeWire guarantees no bundled software with downloads. The open source property of the LimeWire encourages its users to monitor its development. The largest competitor of LimeWire is BitTorrent, which is very efficient in sharing large files (BitTorrent, 2006). Its users upload portions of required documents to a requester instead of forcing one client to upload the whole file many times.

THE PROBLEM OF THE INTRUSION

Computers connected to networks are to be protected by different means (Kemmerer & Vigna, 2002). Information stored on a computer can be personal or business character, private or confidential. An unauthorized can person can therefore steal it; its possible cases are shown in Table 1.

We have to protect not only our data, but also our resources. Resources are not necessarily hardware only. Typical types of attack are to gain access to a computer to initiate other attacks from it. This is to make the identification of the attacker more difficult because this way the next intruded host in this chain sees the IP address of the previous one as its attacker.

Stored data can not only be stolen, but changed. Information modified on a host is extremely useful to cause economic damage to a company. The attacker can alter or obstruct its functioning properly and cause damage.

Intrusion attempts, based on their purpose, can be of different methods. But these methods share things in common, scanning networks ports or subnetworks for services, and making several attempts in a short time. This can be used to detect these attempts and to prepare for protection.

Simple, low strength passwords are also a means of security holes. These are used by the so-called dictionary method, trying to log into the system with common names or proper names as somebody's password. They are of a relatively small number and easily guessable.

Table 1. The types of the information stealth

- An unauthorized person gains access to a host.
- Monitoring or intercepting network traffic by someone.
- An authorized but abusive user.

The attacker can also be trying to find resources through security holes. With this type of action, whole ranges of network addresses are scanned for a particular service having a bug or just being badly configured. The port number is fixed here. An example for this is scanning for an open e-mail (SMTP) relay to send junk mail anonymously.

A common feature of the attack methods described above is that the attacker makes *several attempts* against a host. The Komondor software developed by us uses this as a base. As one host running the Komondor detects an intrusion attempt and shares the address of the attacker on the overlay network, the other ones can prepare and await the *same attacker* in safety, who will usually arrive sooner or later.

Traditionally, organizations have relied on their firewall to enforce their corporate policies. To stop the use of P2P file sharing, organizations may add a rule that denies outbound ports not required for business (Sorensen & Richards, 2004). Unfortunately, many of the P2P applications today use a "port-hopping" method of communication to circumvent firewall rule sets that limit outbound connections to specifically allowed ports. If the firewall restricts the ports permitted to establish outbound connections to only the essential ports, such as port 80 (HTTP) and port 25 (SMTP), the P2P application modifies the port that it uses to communicate with other P2P nodes to use these ports allowed through the firewall.

To effectively detect this type of P2P application traffic in an environment requires the use of a device that can examine the contents of the packets allowed through the firewall. *Intrusion detection systems* (IDS) were designed to satisfy this need. These systems are designed to monitor network traffic to look for known signature attack patterns and/or deviations from protocol specifications that represent malicious intent. When potentially malicious traffic is observed, they generate an alert. More importantly, these "detection" technologies lack the capabilities to effectively prevent this traffic, leaving the burden with the administrator to manually investigate and respond.

WAYS OF PROTECTION

The P2P based file sharing software can cause various security problems. There are file sharing programs, which install further software known as spyware. Spyware monitors the browsing habits of the user and then sends the collected information to third parties. Typically, the user gets advertisements based on the data collected by the spyware. This kind of software can be hard to sense and to clean from the system. Before installing any file sharing program, the user should buy antivirus software that can detect the already downloaded spyware on the user's hard drive and prevent the operating system from downloading further spyware programs.

The active network vulnerability scanners such as the NMAP (2006), Nessus (2005), and ISS Scanner (ISS Scanner, 2005) send packets or communicate in some manner with the systems they are auditing. Naturally, they are bound by the physical limitations of the networks and systems they are auditing to send and receive these packets. In other words, scanning can take a long time, especially for large networks (Deraison, Gula, & Hayton, 2005).

In some rare cases, the act of probing may cause instability in the audited system. Network devices such as routers and switches may also be affected by large numbers of port scans, host enumeration, and vulnerability testing. Also, networks change all too often. After the scan has been finished, it slowly becomes out of date as the network changes.

Active network vulnerability scanners may also have a political stigma within large organizations. For a variety of reasons, a system administrator may feel that there is no need to have a third party scan their systems. To compensate for this, a *passive vulnerability scanner* can be deployed in a manner to watch these "off limits" networks and report on their vulnerabilities.

Passive vulnerability scanning is the process of monitoring network traffic at the packet layer to determine topology, services, and vulnerabilities (Deraison et al., 2005). The passive scanners, such as NeVO, monitor for client and server vulnerabilities of a specific network through direct analysis of the packet stream. As NeVO observes network packets, it builds a model of the active hosts on a network and their services. For example, observing a TCP port 25 SYN-ACK packet from one of the monitored hosts will cause NeVO to reevaluate the network model.

NeVO uses different methods to determine if a host is alive and what the host is. It reconstructs both sides of a network conversation and then analyzes the data for evidence of specific client or server vulnerabilities. Unique client and servers for protocols such as HTTP, SMTP, and FTP have unique strings which identify the version of the service. NeVO also makes use of passive operating system identification by monitoring SYN packets which may be emitted by the system during network usage. Each operating system, such as Windows or Linux, builds its SYN packets in its own unique way, and this can be used to distinguish between some specific types.

Passive vulnerability scanning is not a replacement for active vulnerability scanning, but it is a very efficient technology. When it is deployed on its own, the passive vulnerability scanner will produce very interesting information about the security profile of a monitored network. However, this is by no means a full view of network security. When deployed together, both methods will efficiently detect vulnerabilities and changes to the monitored networks (Deraison et al., 2005).

The ability to correctly identify the attacks on the Internet is very important. The exchange of alert information between organizations can greatly supplement the knowledge obtained from local monitors (Locasto, Parekh, Keromytis, & Stolfo, 2005). The IDS usually operates within one administrative domain. Therefore, information about the global state of network attack patterns is usually unexamined. However, global information exchange can help organizations in ranking and addressing threats, which they would not have otherwise identified.

In order to construct an efficient IDS, a lot of problems must be solved before intrusion alert data can be safely distributed among cooperating organizations. For example, distributing all alert information in a P2P overlay quadratically increases bandwidth requirements. Also, information exchange between cooperating organizations must be carefully managed, since confidential network information can be distributed with the alert information by chance.

There are developments to construct a P2P system that can detect and identify attacks in a distributed manner. Krugel, Toth, and Kerer (2001) proved that only a small number of information exchanges need to be exchanged to determine an attack in progress. Their results confirm that a P2P solution is feasible and usable for creating decentralized IDS. They supposed that the attack signatures are known by the systems before the intrusion takes place. The DOMINO overlay system (Yegneswaren, Barford, & Jha, 2004) applies the Chord document routing protocol (Stoica, Morris, Karger, Kaashoek, & Balakrishnan, 2001) to disseminate alert data based on a hash of the source IP address. The DShield project uses a centralized repository to receive intrusion alerts from a lot of distributed sources (Ullrich, 2005). The DShield supports the exchange of information among administrative domains, too.

ALGORITHMS USED IN THE DEVELOPED SYSTEM

This section introduces a novel method, which utilizes the results of the existing IDS methods and efficiently combines the individual security solutions of the operating systems with the P2P technology to construct an overlay of the developed client programs running on individual hosts. The most important algorithms making up the proposed system will also be presented.

The use of the peer-to-peer network model for this purpose is new in principle. Test results proved its usefulness, with its aid were not only simulated, but also real intrusion attempts blocked. The design goal of the system is listed in Table 2.

The proposed method is implemented in software called *Komondor*, which got its name from the famous Hungarian guard dog. The Komondor software is intended to mask the security holes of services provided by the host, not to repair them. For this, it does not need to know about the security hole in detail. It can provide some protection in advance, but only if somewhere on the network an intrusion was already detected. It does not fix the security hole, but keeps the particular attacker from further activity. If the given security hole is already known, it is worth rather fixing that itself.

The inner architecture of Komondor is presented in Figure 1. Different hosts run the uniform copies of this program, monitoring the occurring network intrusion attempts. If one of the peers detects an attempt on a system supervised, it takes two actions:

1. Strengthens the protection locally, by configuring the firewall to block the offending network address.
2. Informs the other peers about the attempt.

Komondor nodes protect each other this way. If an intrusion attempt was recorded by a node, the other ones can prepare for the attack in advance. This is shown in Figure 2.

Information about intrusion attempts is collected by two means: intrusion detected by the node in question or intrusion detected by another one. The first working version of Komondor monitors system log files to collect information. These log files can contain various error messages, which may refer to an intrusion attempt. Possible examples are log-in attempt with an inexistent user name or several attempts to download an inexistent file through a HTTP server (Czirkos, 2005). The actual topology and related data of the Komondor overlay is continuously displayed on the Komondor project page (Czirkos, 2006).

Table 2. The design goals of the proposed system

- Creating a stable overlay network to share information.
- Reports of intrusions should spread as fast as possible over the network.
- Decentralized system, redundant peers.
- Masking the security holes of each peer based on the reports.

CONCLUSION

The article reviewed some security-related problems of the P2P virtual networks and presented many useful and applicable approaches, which address the problem of the intrusion detection. A novel application of P2P theory was also introduced that helps the users of this system to increase security of their hosts.

The developed system is easy to use; the nodes organize the P2P overlay automatically and do not need any user interaction. It proves the reasonability of a security application utilizing local protection and P2P theory together. The dependability of a P2P overlay ensures that intrusion alerts will reach all hosts which need protection. The self-organizing property of such an overlay also ensures that it will remain functional in an environment with a high number of network link failures.

Figure 1. Architecture of the Komondor system

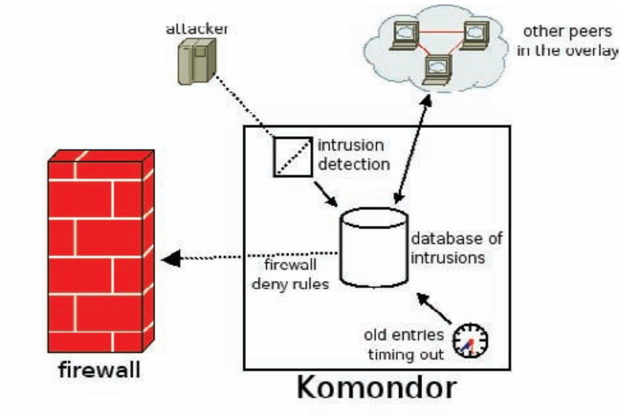
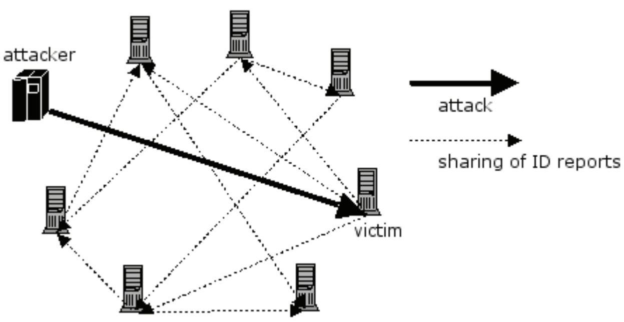


Figure 2. Attack against a Komondor node



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KEY TERMS

Active Network Vulnerability Scanner: Such systems send packets and communicate in some manner with the systems they are auditing.

Application Level Network (ALN): The applications, which are running in the hosts, can create a virtual network from their logical connections. This is also called ***overlay network***. The operations of such software entities are not able to understand without knowing their logical relations. ALN software entities usually use the ***P2P model***, not the ***client/server*** model, for the communication.

Client/Server Model: A communicating way, where one host has more functionality than the other. It differs from the ***P2P model***.

Firewall: This is a host or router which provides a strict gateway to the Internet for a subnetwork, checking traffic and maybe dropping some network packets.

Intrusion Detection System (IDS): Examines the contents of the packets allowed through the firewall. It monitors network traffic to look for known signature attack patterns. When the malicious traffic is observed, the IDS generates an alert.

Overlay Network: The applications, which create an ***ALN***, work together and usually follow the ***P2P communication model***.

Passive Network Vulnerability Scanner: Monitors network traffic at the packet layer to determine topology services. They also try to identify the vulnerabilities of the client and the server in a specific network through direct analysis of the packet stream.

Peer-to-Peer (P2P) Model: A communication way where each node has the same authority and communication capability. They create a virtual network, overlaid on the Internet. Its members organize themselves into a topology for data transmission.

On the Stability of Peer-to-Peer Networks in Real-World Environments

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INTRODUCTION

Communication in computer networks can be organized in two different ways, according to the client/server model and the peer-to-peer model (Spinellis & Androutsellis-Theotokis, 2004). In the client/server model, the network is centralized. There is one host on the network, the server, which provides services to its clients. Its network address is usually well-known. On the other hand, in the peer-to-peer model, there is no central point in the network. Hosts participating are sometimes called "servents" (Gnutella, 2006), as they act both as servers and as clients at the same time: they provide services to other servents, while they also use the services of others.

Nodes in unstructured peer-to-peer networks usually communicate via message flooding. For example, a search request for a given file in the Gnutella network is sent to all neighboring servents. However, this solution is not scalable, and it generates a lot of unnecessary network traffic.

Structured peer-to-peer networks assign unique identifiers, called node IDs, to participating nodes. These overlay networks store key-value pairs. Every piece of information has a key, for example, the name of the file. This key is scrambled with a hash function (Lua, Crowcroft, Pias, Sharma, & Lim 2004), which generates a seemingly random number derived from the key. Then these numbers are used to assign files to specific nodes: each node stores the files, which have their names' hash value numerically close to the unique identifier of the node. That is why structured networks are also called distributed hash tables (DHTs), as for every key, it is easy to find the node which stores the corresponding value. This process is called consistent hashing (Stoica, Morris, Karger, Kaashoek, & Balakrishnan 2001), as every node uses the same hash function. Examples for structured networks are CAN (Ratnasamy, Francis, Handley, Karp, & Shenker 2001), Chord (Stoica et al., 2001), Pastry, and Kademlia (Maymounkov & Mazieres, 2002). These are all DHTs, but they use different topologies and routing mechanisms.

DISTRIBUTED HASH TABLES

In a distributed hash table, a hash function is used to derive a small number from a key representing some data (the value). Information is then stored on one of the participating peers. The application level networks mentioned above all use hash tables to store information, but the exact management of storage is different in the following three aspects (see Table 1):

- The selection of a hash function. Most networks use MD5 or SHA-1. The choice of a function is not really important for this use, as they are only used to make data evenly distributed among the nodes. For example, Kademlia uses SHA-1 (Eastlake & Jones, 2001).
- The selection of a metric function. A metric defines a distance between two IDs, so hashed data can be assigned to specific locations, nodes in the network. Every node stores key-value pairs, which have a hash value closest to its ID, according to the metric function. Kademlia uses the XOR operation.
- The selection of a topology. This is closely related to the selection of the metric function. CAN is usually symbolized as an n-dimensional torus, while it calculates the distance between identifiers by using the Pythagorean Theorem. Kademlia is usually represented with a binary tree. In Chord,

Table 1. Topologies DHT networks

Overlay network	Metric	Topology
CAN	Euclidean	n-dimensional torus
Chord	Subtraction	ring
Kademlia	XOR operation	binary tree

the peers are organized in a ring, and messages are always sent clockwise around the ring.

RELIABILITY IN PEER-TO-PEER NETWORKS

Reliability of a peer-to-peer network is directly influenced by the dependability of the underlying network packet transfer service. The different topologies, however, are affected differently by packet losses and other errors. Most structured peer-to-peer networks, for example, CAN (Ratnasamy et al., 2001), have an exact topology. In the n-dimensional circular torus of CAN, every node has to maintain only a small number of connections; in a two-dimensional example, this number is four (up, down, left, and right). Data to be sent are forwarded (routed) on the overlay network from node to node, finally arriving at their destination. CAN is therefore able to use session-oriented TCP as its transport protocol, as a node always communicates only with its neighbors.

There are other structured networks, which have no specific topology, for example, Kademlia (Maymounkov & Mazieres, 2002). In Kademlia, messages are not forwarded inside the overlay (there is no routing defined), rather they are sent directly between the source and the destination as datagrams. The purpose of the overlay is only to find the physical network address (IP address, port number) of the destination node in question, and it uses UDP for its messages. Therefore, network errors directly influence the communication between peers, and this is especially true for specific source-destination pairs. Permanent network errors, nodes that cannot be reached (because they are behind a firewall, for example), all degrade the quality and performance of the overlay.

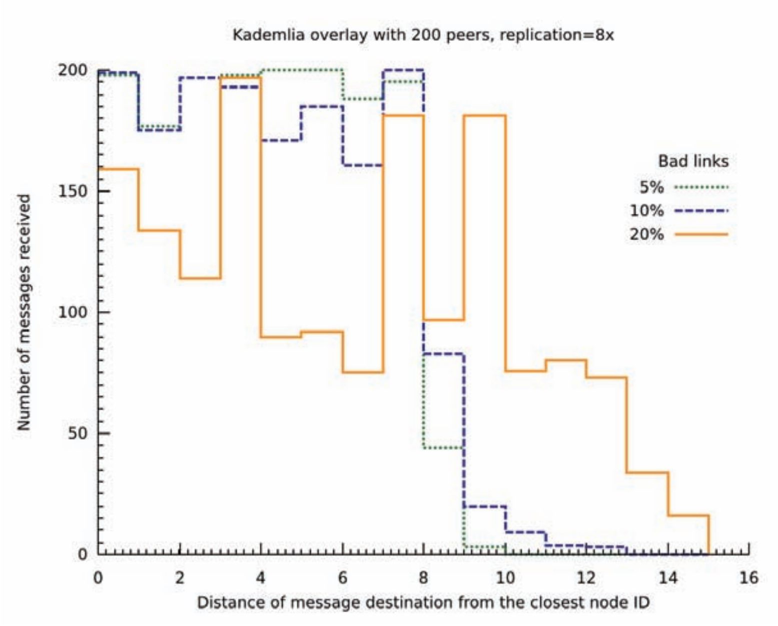
The availability of a specific connection can naturally be tested by a simple ping message. Due to network errors, information available at nodes can sometimes be unreachable for others. The exact distribution of errors is usually highly uneven; with some nodes having good connectivity and others not. This issue can be solved by the data replication. As node IDs are usually chosen randomly, nodes which are close to each other in the application network address space can be quite far from each other in the physical address space, and even geographically. Therefore, sending messages to more than one node, which are close to a specific destination, can result in replicating data at very different locations, almost as if destinations were randomly chosen.

Figure 1 shows our simulation of a random Kademlia overlay topology. The simulated scenario was that we tested all the participating nodes of the overlay (in this experiment, we used $n=200$ nodes) if they are able to send an information message to a certain destination node and some replication of the information message to the closest nodes of the destination. We did not use a real topology, since in Kademlia there is not real topology; in fact, every node can send message to every other. But the success of the sent message was measured by a random variable, namely the ratio of the bad links of each participating node. In this experiment, a replication factor of $k=8$ was selected, which means that every participating node stores its key-value pairs at eight different locations.

The ideal case is when all network connections are functioning, and there are no errors. If there are failing connections, senders of messages choose nodes as destinations, which are not the eight closest ones in the entire network, but a bit further in node identifier address space. This can happen since peers can detect the failing links. (For example, a node is intending to send its message to eight peers, but it detects that the node with the third closest address is unreachable. Then it sends its piece of information to the 9th closest node, too.)

In Figure 1, the three different plots visualize network messages arriving at destination nodes, in case of various ratios of nonfunctioning network links. The *X* axis shows the nodes of the overlay; they are sequenced in the order of closeness to the destination address. X=0 is the closest one; the higher the sequence number on the *X* axis, the further the node denoted by the actual sequence number from the destination node. In other words, X=0 is the primary destination (closest), X=1 is the secondary (second closest), X=2 is the tertiary, and so on. The *Y* axis shows the number of nodes, which could reach the destination. This is the value which is our point of interest. Let us suppose that we have a key-value pair stored in the overlay with 200 nodes, and

Figure 1. Simulation of connectivity in a Kademlia overlay



20% of the links are failing. The information is stored at different locations. We are willing to find a node, which is accessible to almost all the nodes, so anybody can retrieve the key-value pair. This was the fourth node on Figure 1 for the 20% error rate simulation.

As a result of the simulation presented in Figure 1, even with high ratio of bad links in the overlay network, the content replication helped to find a node, which can store the information of the message. With 20% of failed links, the node that was only the fourth closest to the original destination could still receive messages from all other nodes dependably. In case of a high number of such experiments, we found very similar results.

BENEFITS OF USING HASH FUNCTIONS

A hash function can usually take an arbitrary sized file and the generated checksum is always fixed in length, for example, 160 bits. Hash functions have properties, which make them applicable even in cryptography solutions. Some of these properties can also be exploited in the peer-to-peer networks mentioned above.

The first property of the hash function can be utilized so that the result of the calculation does not seem to correlate with the input. For example, the hash value of the word "cat" can have the hexadecimal value FA9823A7, and the word "cut" might yield the value 79EFB2D3. The result can be totally different, even when changing one bit in the input. Its second important property is that the resulting numbers are distributed evenly in the range of the function. This way, in an overlay of many peers, the data to be stored are evenly distributed among them if we store the data files according to the hashed values of the identifiers of the peers (**nodeID**) and the hashed values of the identifiers of the data files.

When we simulate the operation of the Kademlia overlay, sometimes we do not simulate actual IP addresses but we simulate the activity of the peers belonging to the Kademlia by utilizing the properties of hash functions. If a node stores some key-value pair in the Kademlia overlay, first it uses the hash function to scramble the key. The result seems to be a random number, which is evenly chosen from the address space of the nodeIDs. As these nodeIDs of participating peers were also chosen virtually randomly, we end up with simply picking a random number of bad network links for the simulation. This fact simplifies the simulation instead of decreasing the conformance of the simulation results.

PEER-TO-PEER OVERLAYS IN REAL-WORLD NETWORKS

Peer-to-peer networks are usually not that effective on the Internet, as in a computer laboratory experiment. One of its reasons is that many nodes participating in the network are behind NAT (network address translation) or firewalls. Those usually cannot receive incoming connections, but are only able to initiate outgoing ones (P2PRG, 2007). That is a serious drawback in peer-to-peer applications, where the equal role of the participators is a fundamental requirement.

Another important fact, which has influence on the operation of an overlay in a real-world environment that node inside the network, can have good or bad connectivity due to the random network errors. The distribution of network errors is similar to a power-law graph (Albert & Barabási, 2002). In the following simulation, this fact is used.

As mentioned previously, Kademlia does not have an exact topology. To store data in the overlay, a node is required to send FIND_NODE messages to nodes successively closer to the destination identifier. The replies for these messages are IP address, port number pairs; network addresses of other nodes (Maymounkov & Mazieres, 2002). Finally, the node intending to store a datum finds out the Internet address of that node (it will be the destination node), which has its application level address the closest to the hashed key and sends a STORE request directly as a datagram. Due to the inherent network errors, the data will be sent not to the destination node, but to some other nodes close to the destination, depending on the actual value of the replication.

Unlike other overlay networks like CAN, which require nodes to maintain only a small number of connections to neighbors, in Kademlia overlay network, a node (called peer) can send a message to anyone. If we have n=200 nodes in a Kademlia overlay, it is possible for a node to send a message to *any other* participator peer; however, it cannot know for sure that its connection to the destination address will work. The node will get the network address of the destination, but maybe it cannot connect it, for example, because of firewall settings. This is a problem, as data stored far away (in nodeID address space) from the correct destination will not be retrieved by others: they will not request that piece of information there. The most fundamental assumption for a distributed hash table was that every key-value pair is stored in a well defined place. We modeled this distribution with the number of permanently failing links increasing quadratically, based on the power-law graph model (Albert & Barabási, 2002). The ratio for a given peer is then given by:

$$h(m) = c \cdot \left(\frac{m}{n}\right)^{\alpha} \qquad (1)$$

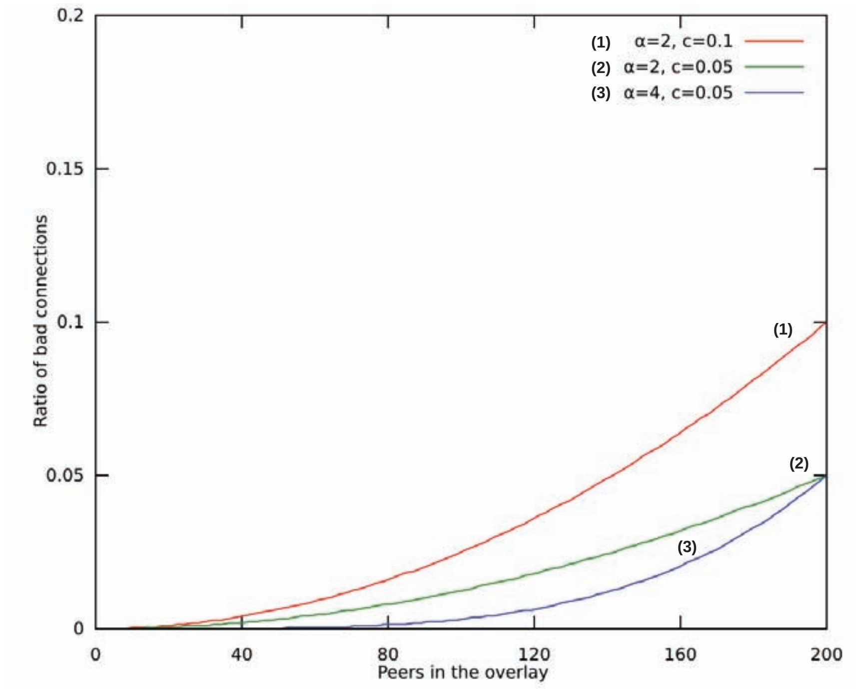
where m is the sequence number of the examined peer, n is the number of all peers ($0 \leq m < n$), α is 2 for a quadratic distribution, and c is a constant, which sets the maximum proportion of errors (ratio of inaccessible neighbors for a specific node). These values can be set experimentally and depend on the size and the actual properties of the Internet network underlying the Kademlia overlay. Local area networks are usually much more dependable than wide area networks like the Internet.

This $h(m)$ function gives the ratio of bad connections for a given peer in case of n=200 for various α and c values, as seen in Figure 2. The X axis shows the parameter m, and the Y axis shows the $h(m)$. The function $h(m)$ should be a stepping function, as the result multiplied by the number of nodes gives the number of bad connections, and the $h(m)*n$ product should be an integer, since it is the number of the bad links. Therefore, this formula is an estimation, as one cannot interpret "0.5 links fail," only 0 or 1, which will be very inaccurate. On the other hand, rounding "10.3 links fail" to 10 failing links is only a small error. Fortunately, we are interested in modeling the operation of the overlay in a heavily error prone environment; the final equation derived in this paragraph is not applicable for a low number of errors.

Remember that as STORE requests end up at destinations, of which nodeIDs can be taken into account as random variables, thanks to the properties of hash functions, it does not really matter which error link ratio belongs to which node. Only the global distribution of the node peers is important and that some nodes can receive most of the messages, some not.

As the underlying Internet network is not perfect, we also cannot expect the overlay to be so. But still

Figure 2. h(m): ratio of bad connections for each node



we can have a requirement, expressed in numeric terms; for example, in 99% of all the cases, we should be able to retrieve the stored key-value pair from the Kademlia overlay. Similarly, the original Kademlia paper (Maymounkov & Mazieres, 2002) gave a probabilistic guarantee for a key-value pair being available for lookup over time. We have the ratio of allowed errors (*β=1%*), and for a lookup to be successful with a probability of *1- β*, the inequality:

$$h(m) \leq \beta \tag{2}$$

should hold for the given node, which is responsible for storing the key-value pair in question and able to answer the request. Due to the fact that the return values of hash functions seem to be random variables and the probability distribution of this random variable is practically equal distribution, the inequality (2) must be valid for every *m* value in the interval [0, *n*]. That is why we can choose *m* freely, so *m/n* is virtually a random number between 0 and 1. Also, nodes chose their identifiers (nodeID) by virtually picking a random number in the address range (due to the properties of the hash function), so this way the stored data always gets to randomly chosen hosts; at least we can suppose it in the terms of simulation and modeling.

If we solve the inequality (2), we get the ratio of nodes, which fulfills our requirements accruing to the allowed error ratio *β*. The solution of the inequality (2) if Equation (1) is substituted is:

$$\frac{m}{n} \leq \sqrt[\alpha]{\frac{\beta}{c}} \tag{3}$$

The right side of the inequality (3) can be interpreted as a condition which must be fulfilled. If it is, a certain piece of information stored in the overlay can be retrieved successfully, too. We denote the probability that the lookup procedure is successful with *P'*. Since $0 \leq m/n < 1$, and randomly changes from 0 to 1 (virtually, due to the hash value), the following equality holds for *P'*:

$$P' = \sqrt[\alpha]{\frac{\beta}{c}} \tag{4}$$

Figure 3. The probability of correct lookups in Kademlia

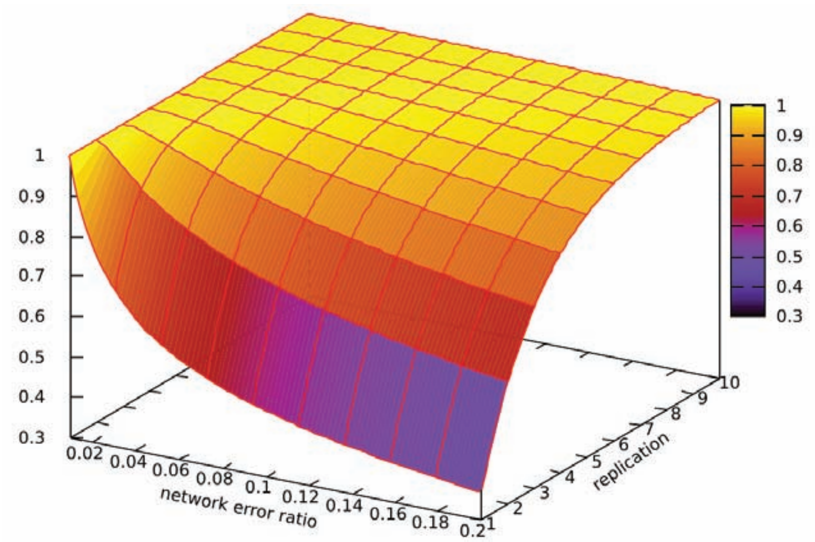
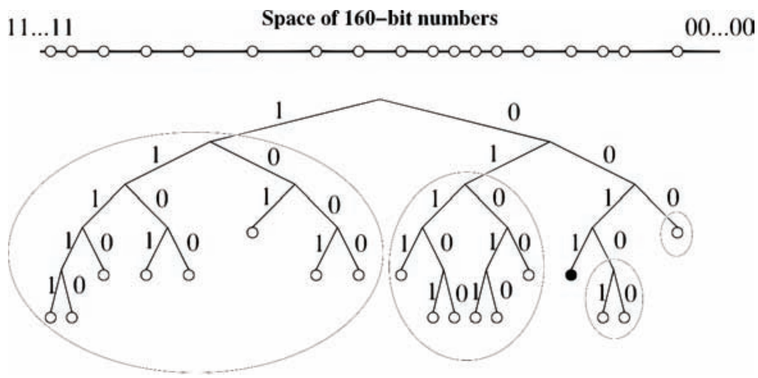


Figure 4. The topology of the Kademlia overlay network



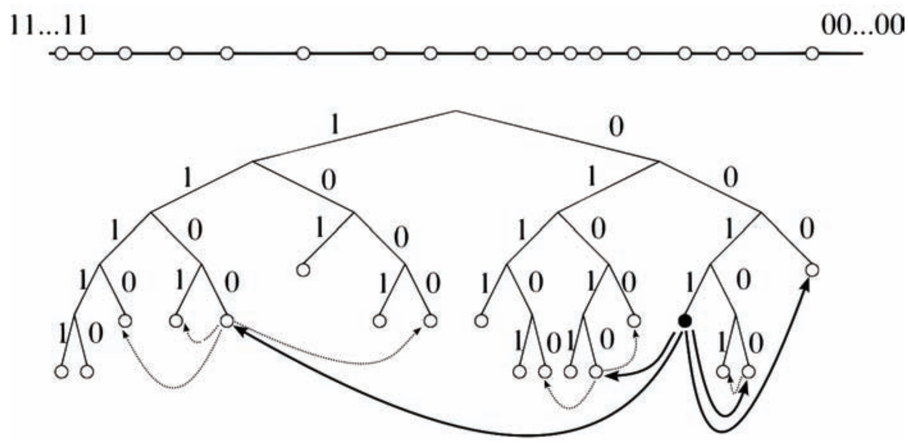
If the Kademlia overlay implements replication *k*, it has more than one, exactly *k* opportunities to store or retrieve data. Practically speaking, it can choose more than one random *m* number, and the probability of correct lookups denoted with *P* increases. Calculating the probability of all lookups failing, and then subtracting that from one, we get:

$$P = 1 - (1 - P')^k , \qquad (5)$$

which gives the probability of successfully looking up a given information despite network errors. In this formula, *k* is the level of replication, the number of nodes storing a given key-value pair.

Equation (5) can be used to estimate the necessary replication factor *k*, if the ratio of network errors and required probability of correctness is given. Figure 3 shows the results for given error and replication levels, with 1% failure allowed. As one can see, for *h*(*m*)=10% of failing links, for example, replication factor of *k=4* is enough to ensure correct operation with high probability (*P*>0.6). This replication factor *k* is essentially the same as the size of the k-buckets in Kademlia (see Maymounkov & Mazieres, 2002 for a discussion). The model we presented here can be used to determine this configuration parameter *k* for such an overlay, as it is a trade-off between dependability and induced network traffic.

Figure 5. Broadcast in the Kademlia overlay



BROADCAST MASSAGES IN PEER-TO-PEER OVERLAYS

Broadcast algorithms are usually not in the focus of research efforts for peer-to-peer systems, while the idea contradicts scalability. However, there are applications where broadcast messages are essential. The topology of a structured overlay can also be used to send multicast or broadcast messages: it can be used as an implicit multicast tree. This is especially true for the Kademlia overlay.

As mentioned previously, the Kademlia system organizes peers into a binary tree using their 160-bit node identifiers (Maymounkov & Mazieres, 2002), as seen in Figure 4. Every node is required to maintain a list of other nodes, which are in the increasing subtrees. These lists are fixed in length and are called k-buckets. The subtrees for the node marked with black are also shown in Figure 4.

When a search or a data store request emerges, the node initiating it subsequently queries nodes closer and closer to the destination address. This is possible because each node has better knowledge about others closer in the address range. As k-buckets are fixed size, this solution is scalable. Every bucket represents a smaller group of peers, always with a factor of two, so the search request is logarithmic in time.

The first possible method to implement broadcast messages in structured overlays is to mark every message with a unique identifier. The identifier can be a random number from a sufficiently large range, or it can be the hash value of the message content. The latter is more useful, while the hash value can also serve as a checksum to test message validity. Messages are then sent to all neighbors, with each node maintaining the list of the recently seen messages and dropping duplicates. This is similar to the controlled flooding used for search requests in Gnutella (2006), but due to the structured topology, much more efficient than that.

In the CAN overlay (Ratnasamy et al., 2001), for a two-dimensional example, this means that every node sends the message to four neighbors: left, right, up, and down. In Chord, the message can be forwarded one step at a time, with every node sending it to its successor on the ring, but the finger tables (see Stoica et al., 2001) can be utilized to implement broadcasting the message exponentially, which yields logarithmic time. Nodes could this way receive messages more than once, but the list of recently seen identifiers ensures spotting duplicates. In the Kademlia overlay, forwarding a

Table 2. Tag values for broadcast messages from 00110

Destination	Subtree depth
11000	0
01010	1
00000	2
00100	3

message means sending it to nodes in every k-bucket (so every neighboring subtree).

For Kademlia, another algorithm is feasible. In this one, messages do not need unique identifiers, but every message is tagged with an auxiliary value, which represents the size of the subtree it is sent to.

Consider the overlay in Figure 5. The node marked with black (having ID 00110) starts a broadcast message by sending it to randomly chosen nodes from all of its k-buckets. Every message is tagged with a number, the depth of the subtree it belongs to. The tag values are shown in Table 2.

As one can see, the tag value is essentially the number of bits which the source and the destination share on the most significant bits of their addresses. This way every receiver of the message knows which subtree in the complete overlay it is responsible for. That is why the node on the right hand side, with identifier 00000, does not have to forward the broadcast message. The second burst of messages is drawn with dotted lines. Note that this algorithm heavily depends on the requirement in Kademlia for every node to keep track of its close neighbors' Internet addresses.

A similar approach for the Chord overlay is introduced in El-Ansary, Alima, Brand, and Haridi (2003). Both algorithms depend on routing information in the overlays being correct, which may not be the case in a high-churn environment, where nodes frequently join and leave the network. The redundancy of the first algorithm shown here can be the key to solve this issue, too.

CONCLUSION

In this article, we presented some aspects of peer-to-peer networks operating in real-world environments. We have shown that replication of data is important in situations where network errors and bad connectivity sets back the correct operation of overlays. We also simulated the modeled the Kademlia network in such conditions and determined the level of replication which is required for successful operation. As the number of computers connected to the Internet grows exponentially, the network address space becomes a bottleneck. Therefore, solutions for sharing public network addresses are very common. Unfortunately, those usually mask the full potential of peer-to-peer overlays. This article presented the inherent flexibility of those application level networks and the ways they can overcome these obstacles and increase their dependability at the same time. By using replication, each participant is able to find information stored in the overlay network with high probability.

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KEY TERMS

Application Level Network (ALN): The applications, which are running in the hosts, can create a virtual network from their logical connections. This is also called an overlay network. The operations of such software entities are not able to understand without knowing their logical relations. ALN software entities usually use the P2P model, not the client/server model for the communication.

Client/server Model: A communicating way, where one host has more functionality than the other. It differs from the P2P model.

Datagram: A short, separate message between computers, similar to a conventional letter. A typical protocol to send and receive datagrams over the Internet is UDP, the User Datagram Protocol. See “Session.”

Distributed Hash Table: A hash table stores key-value pairs and enables a fast lookup for every value (piece of information), given its key. DHTs are application level networks, functioning as hash tables which span across many computers. A hash function is used to map each key-value pair to a specific computer in the network so that other participants will know from where to retrieve it.

Firewall: This is a host or router which provides a strict gateway to the Internet for a subnetwork, checking traffic and maybe dropping some network packets.

Hash Function: A mathematical formula, which is used to turn some data into a representing number, which can serve as a digital fingerprint. These formula can usually be applied to any data and create a seemingly random but reproducible identifier. Example algorithms for this are MD5 and SHA-1.

K-bucket: A list of a node’s neighbors in the Kademlia overlay.

Key-value Pair: The fundamental unit of information stored in a hash table. Every piece of information content (value) is assigned an identifier (key), which is used for reference: values are mapped onto keys. An everyday example for this is a name of a file and its content.

Network Address Translation: Two or more network hosts sharing the same Internet address. One of the hosts serves as a gateway and forwards network packets between the Internet and the local network.

Overlay Network: The applications, which create an ALN, work together and usually follow the P2P model.

Peer-to-Peer (P2P) Model: A communication way where each node has the same authority and communication capability. They create a virtual network, overlaid on the Internet. Its members organize themselves into a topology for data transmission.

Replication: Storing data at different physical locations to enhance availability and dependability.

Session: An established channel for messages between two computers, similar to a conventional phone call. On the Internet, the TCP (Transmission Control Protocol) is used mostly to implement session-based communication. See “Datagram.”

Online Catalog of Manuscripts Conserved in Libraries in the Veneto Region

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INTRODUCTION

In 2003 the Veneto Regional Council set up a project to catalog all manuscript holdings in libraries in the Veneto region, in order to provide a freely accessible, uniform online open catalog (1) via shared cataloguing standards. The implementation of this project entailed coordinating its scientific and organizational aspects, as well as checking and revising the catalog descriptions. The Biblioteca del Museo Correr was in charge of coordinating the project, which had previously set up a cataloging project of its manuscript holdings in 2001, starting with its oldest holding, the Teodoro Correr collection. The coordinating team, composed of Paolo Eleuteri, Barbara Vanin and Francesco Bernardi, and later also Alessia Giachery, initially created a catalog data sheet model, which features a brief description that is suitable for the mainly modern material present in the libraries (2). It provides a brief codicological description and a more detailed description of the manuscripts contents. At the same time *Guidelines for cataloging manuscripts* (3) were set out, which provided the framework in terms of cataloging for the MANUS software system developed by the Istituto Centrale per il Catalogo Unico delle biblioteche italiane. Together with the Veneto Regional Council an initial group of libraries of various typologies were selected, which completely lacked catalogs or adequate tools to access their manuscript holdings. They were asked to present targeted cataloging projects.

THE PROJECT

In the first year of the project (October 2003 - December 2004) cataloging was undertaken using the MANUS system, with the aim of sending the data to the ICCU, which would publish the information in its catalog, accessible at http://manus.iccu.sbn.it. However, revision of the data sheets immediately highlighted the difficulty of achieving uniformity when working from "isolated" cataloging. This unsystematic form affected information retrieval for research, making it difficult for users to access data easily. Moreover, the ICCU could not guarantee prompt and immediate publication of the results of the cataloging. Bearing in mind these considerations, the Veneto Regional Council during the years 2004-2005 assigned to the Biblioteca del Museo Correr the task of creating a new online manuscript cataloging software system. The result was the *Nuova Biblioteca Manoscritta* (NBM) presented here, which is the name of the regional project site, the catalog, as well as the name of the cataloging software itself. Clicking on www.nuovabibliotecamanoscritta.it provides access to the catalog of manuscripts from the libraries taking part in the project (4), gives the reader information about the project itself, the technology used and the libraries. Furthermore, catalogers and administrators are provided with a login and password, to access the software for the cataloging of manuscripts via the Web. The NBM uses a browser via the Internet to upload the catalog records and enables several libraries to share cataloging by working on the same database. Indeed, all catalogers share data relating to name and title headings, and bibliography. This solution facilitates the retrieval of previously compiled information, and above all enables revisers to modify information, in the spirit of an open catalog that can be constantly improved upon.

The software, developed by Idoru s.r.l. in Padua, consists of a data input module solely for catalogrs and a consultation module for the public. The NBM comprises a relational-type database and Web application, and the server-side application is installed on the Unix platform, whereas client application is accessible via a simple Web browser on each platform. The NBM software system precisely imitates the MANUS system for several reasons: the exhaustive information following the guidelines laid down by the ICCU (5), integrated by the MANUS system, the need to transfer all descriptions previously compiled on the MANUS system to the NBM, and last but not least the need to continue sending data to the ICCU, exporting it from the NBM. This is another reason why the Veneto Regional Council cooperated with the ICCU, monitoring the updates and technical and scientific development of the MANUS system.

The catalog, which is freely accessible to users who click on the site, provides a simple search (any word included in each descriptive field, which can also be filtered by library) and an advanced search, where the user can search information by word within a single field and combined fields, by shelf mark, name and title headings of the published manuscripts. A search by text language and subject choosing from a predetermined list shared by the catalogers has also been provided.

From the point of view of shared cataloging that gathers together libraries that are typologically different, it was deemed necessary to administrate libraries and catalogers through a central coordinating team and for the same reason a work schedule was designed that could efficiently coordinate all the activities. Hence, different profiles for the members taking part in the project were defined and designated as follows:

- **Administrator:** Coordinates activities, is a technical and scientific consultant, revises and publishes the records, assigns and deactivates access passwords, and mediates discussion forums;
- **Reviser:** Corrects the data sheets, and directly modifies the lists of name and title headings and bibliography, if authorized by the administrator;
- **Cataloger:** Only has access to manuscript data sheets being cataloged and shares lists with other catalogers;
- **Librarian:** Views all manuscripts in the library, and can intervene on the data sheets produced by the cataloger in the library, if authorized by administrator.

The procedure for revision includes constant monitoring of the manuscripts and their different stages of completion. Revision is also managed via the Web. When the cataloger is compiling a data sheet, the manuscript is in *work in progress.* Once description has been terminated, the cataloger changes the state to *completed.* At this point the reviser checks the data sheet and, if necessary, adds corrections, thereby changing its state *to be checked again.* The cataloger adds his/her own corrections and the sheet becomes *corrected.* After checking these corrections and if there are no other elements to be added, the reviser decides that the manuscript can be *published.* Whenever the manuscript needs updating or modifying, the published manuscript returns to the *work in progress* state, while for research the previous manuscript data sheet is still available until the new description is published.

At this point the main features of the NBM system should be outlined:

- Separate profiles for catalogers, librarians, revisers and administrators;
- Catalog data sheets conforming to the model set out by the ICCU;
- Identification of features common to manuscripts listed by type of binding, script and illustrator;
- Cross-reference among names by official, variant and alternative form;
- Fields designating language, subject, contents and literary genre (can be searched by the catalog);
- Internal description organized on different levels, with the possibility of assigning collective titles;
- Template containing manuscript data preview while in completion;
- Shared list of collections, names, provenance, titles, bibliography, old libraries and subject;
- Management of shared lists with sole insertion option (for catalogers);
- Management of manuscripts according to status: work in progress, completed, corrected (for catalogers);
- Management of manuscripts according to status: to be revised or published (for revisers);
- Management of images.

Working for two years on the project has enabled us to fully understand the difficulties and problems encountered when combining manuscript cataloging and IT. In Italy, there have been other experiments similar to the MANUS project (http://manus.iccu.sbn.it), and two of these in particular should be mentioned. On a regional level a project was set up in Tuscany, where around 2,700 medieval manuscripts dated prior to 1500 are available online. Cataloging has almost been completed and descriptions of printed sources are currently being transferred (www.cultura.toscana.it or www.sismelfirenze.it/CODEX/codex.htm). On a local level there is the open catalog of the manuscripts holding in the Biblioteca Malatestiana in Cesena (www.malatestiana.it/manoscritti), which is quite unique in Italy. As for foreign projects, of which there are many, we will just mention the cataloging of medieval manuscripts in Germany, where at www.manuscripta-mediaevalia.de the description of over 60,000 codices is now available to researchers. The German project, working to an extremely substantial budget, in particular demonstrates how central management and carefully chosen catalogers lead to excellent results. In our experience the greatest problems were recruiting and training people qualified to catalog manuscripts. The coordinating team, as well as visiting each library and examining the projects proposed, setting out descriptions suitable for the various types of manuscripts and commencing cataloging itself, concentrated specifically on the selection and training of catalogers. They are graduates whose subjects are usually in the fields of books and manuscripts in particular. Some have specialized degrees and masters in specific subjects. Nevertheless, most of them had never cataloged a manuscript, which is not so unusual amongst paleographers and professional cardiologists, either. Indeed, cataloging is rather different from studying writing and its other aspects, whether material or not, to be found in a codex. Experience comes with work in the field itself, as well as with training (6). Catalogers who are qualified in different ways produce different types of data sheet descriptions, as well as varying in the amount of time taken to do this, which affects revision and hence the need sometimes to send the work back for further examination. It should be said that in this case the referents from each library, which cooperated with correction and work monitoring, closely working with the coordinating team, proved highly useful. Compensation for each manuscript was difficult to quantify, and was basically calculated on the basis of the degree of detailed information present in the data sheet and on the average time taken by an expert cataloger. In order to explain what was observed, a brief description of the difficulties encountered in revising the records will now follow.

In the first place, there existed the problem of using IT for cataloging manuscripts. Cataloging field by field, which the software usually proposes, means that the cataloger tends to focus on individual fields and thus loses sight of the manuscript's complex whole, so that the resulting record is often inconsistent or unbalanced amongst its various parts and is not always easy to consult. There were also some problems experienced in understanding the "philosophy" of a program such as MANUS, which does not allow multi-level description for composite manuscripts, and when dealing with analytical internal descriptions listing a single collective title without using the *Camicia* area belonging to the external description of the manuscript. Indeed, it was often the case that sections of a work were listed at the same level as the title heading of the work itself, sometimes relegated in *Camicia*. This was precisely due to the problem of adapting cataloging by field to the manuscript's complex whole.

As a result of this experience, in the NBM system it was decided to gather together on one screen all the fields of one area and to display at the bottom of the screen the record during work in progress for the cataloger, in the form of a search report. The NBM system enables the cataloger to make choices. Once a work has been assigned a title and indexed in the shared lists, the cataloger can decide whether to index the sections of a single work with its own titles (as in the case of anthologies or florilegia with their own history), or else to supply a detailed description of the sections, without providing the various chapters, parts, books, and so forth. with a title of their own. In the final record the sections appear and can be searched by word, whereas the sections having their own history appear in the list of titles and are searchable by index.

A further problem encountered is the fact that most collections to be cataloged are made up of modern manuscripts. This type of manuscript, unlike the medieval codex, does not have an established cataloging tradition and for many complex reasons the resulting implications have not been thoroughly analysed so far.

The concept of information sharing and consistency when cataloging online were other problematic areas that were discussed when creating a program that would provide extended ongoing lists of name and title headings and bibliographies and also guarantee cataloge uniformity and access points. One only has to think of the various catalogers, 21 libraries and 30 catalogers have participated in the project), working in different locations, who create lists of name and title headings that are inevitably different when using a local program. When constructing authority records, they may produce cross-references to sources that are based on each cataloger's personal knowledge and on the availability of the information on the territory, which may result in inconsistency. As foreseen, revision was slow and complex, producing a cataloge that was not uniform and hence almost inaccessible. Sharing enables the cataloger to extract useful information from the lists, thus reducing cataloging time: an official name is linked by cross-reference to the manuscript repertory, which only has to be verified, and a conventional name can be more easily recognized and identified by other catalogers; a uniform title is linked to the author with relative notes and also by cross-reference to the repertory or edition. This means that the coordinating team has to verify and monitor the process constantly, correcting errors in the lists and providing official name and title headings, in the logic of an open catalog.

Those catalogers who were familiar with the SBN system were obviously at an advantage when implementing this type of cataloging, so different from the traditional cataloging of manuscripts that only had to guarantee and conform to internal consistency. Knowing how to deal with problems of consistency in assigning names and headings, being familiar with the RICA and SBN index guidelines, and being aware of the problems of incorrectly inserting data in a shared catalog have highlighted the problems of online cataloging compared to traditional card cataloging methods. The NBM system, which is currently importing over 3,000 manuscripts and letters from the MANUS system, aims to standardize catalog entries, thus guaranteeing accurate cross-references between entries and manuscripts according to present standards and studies, and enables constant modification. Whenever an entry is modified in a list it is also modified in all the associated manuscripts at the same time. The work is indeed laborious, but the quantity of data, the cataloging time involved that cannot be compared to the time taken to catalog printed books, and the processing of a small number of manuscripts at a time means that the database can be kept under control. It is hoped that once a sufficient number of manuscripts have been inserted, the catalogers themselves, when looking through different types of published records, can standardize their descriptive style, solve the same problems in a uniform manner and have access to substantial lists of name and title headings and bibliographies that can be captured or increased by applying the same criteria. Hence, it was also deemed important to set up a discussion forum within the NBM, so that project members could exchange ideas and proposals and obtain external contributions.

FUTURE TRENDS

The transfer of data from the MANUS system to the NBM was completed in the summer of 2006 and contains all information concerning holdings deposited in the following libraries: Museo Biblioteca Archivio of Bassano, Biblioteca Lolliniana of Belluno, San Francesco della Vigna of Venezia, the private library Andrighetti Zon Marcello of Venezia, Seminario di Vittorio Veneto, amounting to around 800 manuscripts, to which can be added 2,200 and 3,000 letters from the other libraries: the Biblioteca civica of Belluno, the Biblioteca civica of Padova, the Biblioteca dell'Accademia dei Concordi of Rovigo, Biblioteca capitolare della Cattedrale of Treviso; la Biblioteca del Museo Correr of Venezia, la Fondazione Querini Stampalia of Venezia, la Biblioteca del Museo di Storia Naturale of Venezia, la Biblioteca civica of Verona, the Biblioteca del Museo civico di Storia Naturale of Verona, the Biblioteca civica Bertoliana of Vicenza, the Biblioteca del Gabinetto di lettura of Este and the Biblioteche venete dell'Ordine dei frati minori. At the same time cataloging in the NBM system was commenced, thus making available to the public a further set of 1,500 codices as well as letters. A particular type of software that provides more detailed cataloging and images is to be developed to meet the needs of libraries that house music manuscripts. The NBM system will also include study and reference tools, which will be digitized and made available to scholars. The project undertaken by the Biblioteca del Museo Correr concerns the digitization of the manuscript catalog of the library of Emmanuele Antonio Cicogna, which has around 4,500 codices, compiled by Cicogna himself in seven descriptive volumes and six indexes. Through the NBM catalog it will be possible to access the pages of this precious scholarly tool and search by present and past shelfmark, by author and by manuscript date.

Since July 2005 around 10,000 manuscripts have been published, proving that online cataloging and management leads to a daily increase in the number of available records and that it seems to be successful in processing the vast number of manuscripts housed in Italian libraries. Nevertheless, experience has taught us that these kinds of enterprises cannot be embarked upon without the support and solid determination of institutions, libraries and scholars that are confident of the success of this initiative.

NOTES

- This project is in addition to another initiative promoted in the Veneto region, concerning the cataloging of medieval codices. Two publications have resulted from this initiative: *I manoscritti della Biblioteca del Seminario Vescovile di Padova*, edited by A. Donello, G.M. Florio, N. Giovè, L. Granata, G. Mariani Canova, P. Massalin, A. Mazzon, F. Toniolo, and S. Zamponi, Florence 1998, and *I manoscritti di Padova e provincia*, edited by L. Granata, A. Donello, G.M. Florio, A. Mazzon, A. Tomiello, and F. Toniolo, Florence 2002.
- The description of modern manuscripts has only recently been methodologically discussed. See, for instance, the Proceedings of the conference in Trent on 10 June 2002, *Manoscritti librari moderni e contemporanei. Modelli di catalogazione e prospettive di ricerca*, edited by A. Paolini, Trent 2003.
- This can be consulted at http://lettere.unive.it.
- They are currently: Bassano del Grappa, Museo Biblioteca Archivio; Belluno, Biblioteca civica; Belluno, Biblioteca Lolliniana; Este, Gabinetto di lettura; Padova, Biblioteca civica; Padova, Biblioteca del Seminario maggiore; Rovigo, Biblioteca dell'Accademia dei Concordi; Treviso, Biblioteca capitolare della Cattedrale; Treviso, Biblioteca del Seminario vescovile; Venezia, Biblioteca Andrighetti Zon Marcello; Venezia, Biblioteca del Museo Correr; Venezia, Fondazione Querini Stampalia; Venezia, Biblioteca del Museo di storia naturale; Venezia, Biblioteca San Francesco della Vigna; Verona, Biblioteca civica; Verona, Biblioteca del Museo civico di storia naturale; Vicenza, Biblioteca civica Bertoliana; Vittorio Veneto, Biblioteca del Seminario vescovile. The Biblioteca civica di Feltre and the Franciscan convents in the Veneto province are expected to take part in the project as from next year.
- *Guida a una descrizione uniforme dei manoscritti e al loro censimento*, edited by V. Jemolo and M. Morelli, Rome 1990.
- Some interesting indications on the subject can be found in *Riflessioni di un catalogatore di libri manoscritti* by Paul Canart, published at www.let.unicas.it/links/didattica/palma/testi/canart1.htm.

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KEY TERMS

Libraries: Twenty-five libraries have taken part in the project.

Manuscripts: Cataloging of medieval and modern manuscripts housed in libraries in the Veneto region.

Nuova Biblioteca Manoscritta: Project title. The Nuova Biblioteca Manoscritta is the online catalog which has been produced as part of a project to catalog the manuscripts conserved in libraries in the Veneto region, as well as the name of the software system developed to describe these manuscripts.

Open Catalog: Permits real-time constant catalog update

Online Cataloging: Manuscript cataloging via the Web.

Online Management: Work of revision and publication managed via the Web

Opac Search: Database search tool, via simple search (by word using Boolean operator) or advanced (by combining terms from different fields)

Shared Resources: Information sharing among catalogers (lists of: name of person, corporate body and location, title heading, subject, collection, ancient libraries, bibliography)

Veneto Region: Geographical area in which project members are working (Venezia, Padova, Treviso, Rovigo, Belluno, Verona, Vicenza, Vittorio Veneto, Basano del Grappa, Monselice, Este, Feltre).

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Online Learning's Future in the Workplace with Augmented Reality

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INTRODUCTION

Augmented reality is a technology system that enhances one's perceptions and experiences by overlaying digitized images onto real world environments. By looking through the display lenses of special eyewear, the seamless, information-rich, composite view that can be seen enhances understanding of the real world. As the technology that enables augmented reality evolves, auditory and haptic information overlays will be added, making the user's experience far more vivid. Augmented reality has enormous potential for workplace e-learning and productivity improvement. Prototypes are currently in research and development for military, K-12, and university application. It is anticipated that advances in technology will make augmented reality a common learning tool within the next decade (Azuma, Baillot, Reinhold, Feiner, Julier, & MacIntyre, 2001).

Today's augmented reality system meets the broad definition of e-learning: learning that uses a network for delivery, interaction, and facilitation (Keengwe, 2005). Augmented reality is delivered to the learner via a local area network (LAN), wide area network (WAN), or the Internet. Wireless access has enabled flexible mobility and location independent e-learning, extending opportunities for outdoor and field-based workplace learning far from the classroom computer monitor (Doswell, Blake, & Butcher-Green, 2006). Research is currently underway to tap the potential of augmented e-learning using a networked online learning management system (LMS) (Yu, 2006). It may one day be possible to log in to an online learning management system to access augmented reality e-learning at a work site anywhere in the world whenever the need arises. Though still in development, augmented reality e-learning has the potential to provide immersive, situated learning in the workplace. This article will focus on how augmented reality works, current research and prototypes, and future potential applications of augmented reality in e-learning.

SCENARIO 1: THE POTENTIAL OF AUGMENTED REALITY IN WORKPLACE LEARNING

Imagine a 30-person Army platoon patrolling an enemy city, wearing camouflage and goggle-like, see-through head mounted displays as seen in Figure 1. As the soldiers approach the center of the city, a warning is broadcast through their headphones from the command center 20 miles away; insurgents have been spotted approaching the American Embassy a half mile to the south. Moving cautiously, the platoon changes course and heads toward the target. Several minutes later, another broadcast warns that the insurgents have entered the embassy. As the soldiers approach, they take a moment to view the building through the eyepieces of their head mounted displays. They can see not only the outside of the building but also the outline of each interior room, doorway, hall, and staircase (Bradt, 1997). It is as if the eyepieces have given them X-ray vision, enabling them to see through the building (Azuma, 2004). Another warning is heard through their headphones, spoken in a much quieter voice: activity has been spotted on the third floor, northwest corner of the embassy. The soldiers scan the outline of the building's interior layout and plan their entrance strategy. Identifying a path through interior doors, stairs, and hallways that will provide the best cover while allowing quick access to the target, they deploy. Twelve soldiers enter the building; the rest take up positions around the perimeter and wait as those inside move toward the enemy. Gunfire is heard coming from the

Figure 1. U.S. Navy wireless head mounted display (HMD) From "Eye on the Fleet Photo Gallery," by the U.S. Navy, 2006, http://www.news.navy.mil/. (U.S. Navy photo by John F. Williams (Released))

northwest corner of an upper floor. After several long moments of silence, the sound of heavy footsteps and loud voices is heard coming down the stairs toward the outside doorway. It is time to debrief. Was their strategy successful? Could they have planned a more effective strategy? The soldiers are focused on learning from their mistakes in preparation for their imminent deployment to the war zone.

Augmented Reality

The technology of augmented reality (AR) made it possible for the platoon to "see through" the building. Augmented reality enables users to view the real world enhanced by the addition of computer-generated, or virtual, images. Each virtual image is aligned with its related real world object so that the real and virtual images appear to coexist. A view of augmented reality as seen through a head mounted display is shown in Figure 2. The virtual electrical wires seen on the wall match the exact placement of the actual wires inside the wall (Azuma, 1997). The addition of virtual images enhances the viewer's perception and augments their experiences in the real world environment (Azuma, 2004).

Many image formats are used in augmented reality: graphics, diagrams, drawings, text, short movies, and avatars, or virtual people (Shelton, 2002). Displayed images can be 2- or 3-dimensional (Regenbrecht, Baratoff, & Wilke, 2005), depending on the environmental context. Figure 2 shows a head mounted display view of 2-dimensional wiring behind a wall. Figure 3 shows a head mounted display view of a 3-dimensional character and church created to bring art history to life.

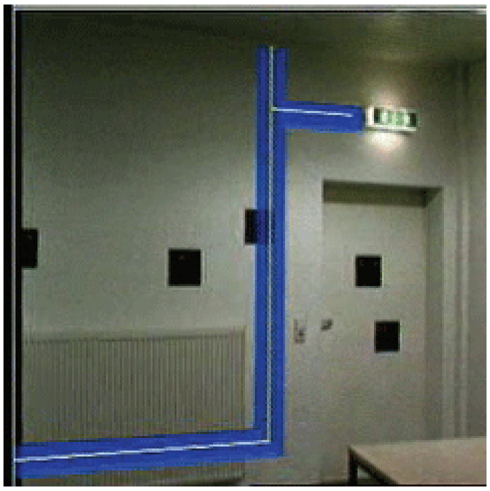
Augmented reality immerses participants in workplace contexts that closely match the actual contexts of their jobs. This contextual approach to learning is consistent with principles of adult learning theory: adults need to know why they need to learn something; adults prefer the learning context to be practical and applicable; and adults are motivated to learn when it will help them better cope with actual job and life tasks (Knowles, Holton, & Swanson, 1998). Contextual learning facilitates the development and retention of skills and knowledge and active engagement in problem solving (Brill, 2001). Some experts theorize that the contexts of work and job-related learning are intertwined with workplace knowledge. According to Eraut (1994):

Professional knowledge cannot be characterized in a manner that is independent of how it is learned and how it is used. It is through looking at the contexts of its acquisition and its use that its essential nature is revealed. (p. 19)

Enabling Technologies

Augmented reality images are dynamic, changing in response to user movement. As the user moves while viewing images through a head mounted display, the images alter to accommodate the person's perspec-

Figure 2. An augmented reality view of electrical wiring. Reprinted courtesy of Fraunhofer IGD and ZGDV, Germany. (Copyright 2007, Gundrun Klinker. Used with permission.)



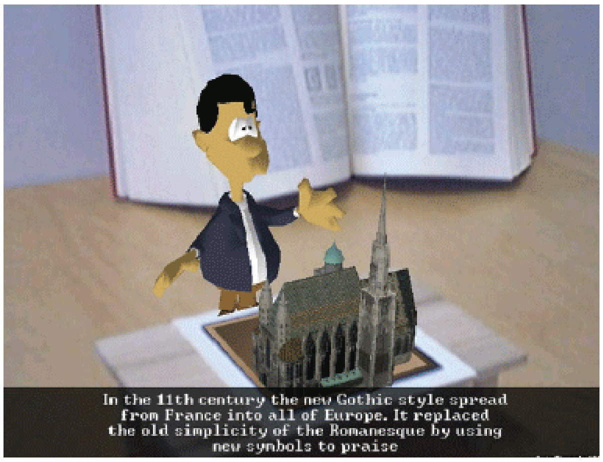
tive. Figure 4 illustrates the changes made to images in response to user movement. Viewed from a body position facing the front of the image, the image looks as it would in reality. When the body position moves to the right, the image changes so that it continues to look like it would in reality (Bonsor, 2001). Four technologies are required to make it possible to view such real-time, dynamic, 3D images: a powerful computer to render images; a network to transfer the images to the learner; a system to track user movement and orientation, such as a global positioning system (GPS) or a tracking device (acoustic, mechanical, magnetic, or vision tracker); and a visual display, generally a head mounted display, through which to view virtual images and the real world (Mahoney, 1999). Figure 5 illustrates the way in which the four technologies work together to create augmented reality (Zlatanova, 2002).

The learner carries the computer with network access, a tracker, and head mounted display. Ideally, the computer and tracker are incorporated into one wearable unit, such as a backpack, to enable ease of movement and use of hands (Bonsor, 2001). The head mounted display is securely attached to a helmet or strap. The tracking system has two components: one worn by the person, the other built into the surrounding environment (Feiner, 2002). As the technology advances and computers and head mounted displays become smaller, the wearable augmented reality system will become less cumbersome. It has been speculated that an augmented reality system may one day be mass-marketed as "the Walkman of the 21st century" (Bonsor, 2001).

SCENARIO 2: THE POTENTIAL OF AUGMENTED REALITY IN WORKPLACE LEARNING

Imagine another platoon of 30 soldiers patrolling the northwest sector of an enemy city known as Quadrant Four. Walking slowly, wearing head mounted displays, or "windshields" (Julier, 2006), with attached stereo ear buds, and a backpack containing tracking sensors and a powerful personal digital assistant (PDA) with wireless Internet access, they carefully study each intersection and building while remaining alert and aware of their surroundings. Suddenly, a car bomb explodes 100 yards away. The soldiers take cover and try to listen to orders coming through their ear buds, but the sound of the explosion was deafening, making hearing difficult. Waiting for the call to move out, the men and women check their weapons and spend a moment in silence waiting for their heart rates and adrenaline levels to return to normal. The all-clear call finally comes and they leave the safety of cover. When the platoon is 25 yards from the bombsite, machine gun fire erupts from rooftops all around them. Startled, they wildly look all around as they realize that this part of the city is surrounded by high walls with few places

Figure 3. Augmented reality view of a 3-D character and church created to bring art history to life From "How *Real Should Virtual Characters Be?" by D. Wagner, M. Billinghurst, D. Schmalstieg, 2006, In Proceedings of the ACM SigCHI International Conference on Advances in Computer Entertainment Technology 2006 (ACE 2006). (Copyright 2006, D. Wagner, M. Billinghurst, D. Schmalstieg. Reprinted with permission.)*



to seek cover. Panic ensues as several soldiers are hit by gunfire before the sergeant calls an end to the training activity. This experience has made quite clear the need to "learn" Quadrant Four so that they can avoid the Mogadishu experience of getting lost in the streets of a war zone (Heltzel, 2002). The platoon will return to the windowless block "buildings" that make up the geographically correct city to spend another day learning Quadrant Four in preparation for their deployment to the war zone.

The Potential of Augmented Reality in Learning

Multisensory immersion has been shown to aid learning (Dede, Salzman, Loftin, & Sprague, 1999). Augmented reality has the potential to apply not only to vision, but also to hearing, touch, and smell (Azuma et al., 2001). Three senses were involved in the second scenario. In addition to the visual image of a bomb exploding, the sound of an explosion could be heard and bullets could be felt striking the body. With simultaneous visual, auditory, and haptic input, participants were immersed in the experience and reacted at a visceral level (Kurzweil, 2006). The multisensory immersion of augmented reality facilitates rapid learning in preparation for critical situations.

The burden of carrying cumbersome equipment should be relieved as advances are made in technology. Head mounted displays are expected to one day resemble a regular pair of eyeglasses, eliminating any fashion concerns (Azuma, 2004). Handheld computers, personal digital assistants (PDAs), and mobile phones are being used in some current augmented reality e-learning prototypes (Klopfer, Perry, Squire, & Ming-Fong, 2005). Though the global positioning system is used in some prototypes, the location information it currently provides can be yards off the mark, requiring the addition of another tracker. As error correction techniques and availability improve, use of global positioning may become common in augmented reality e-learning (Zlatanova, 2002).

The Potential of Augmented Reality in E-Learning

Both combat scenarios highlight the enormous potential of augmented reality e-learning. Training participants can experience dangerous or unusual situations while remaining in the safety of a controlled learning environment (Information in Place, 2004). Learning opportunities can be brought directly into the workplace without causing the disruption to workflow that can

Figure 4. Changing view of image in response to user movement. From "Modelo de Contexto Para Realidad Aumentada, " by Andres Agudelo, 2004, http://aagudelo.control-systems.net/2004/10/publications.html. (Copyright 2004, Andres Agudelo. Reprinted with Permission.)

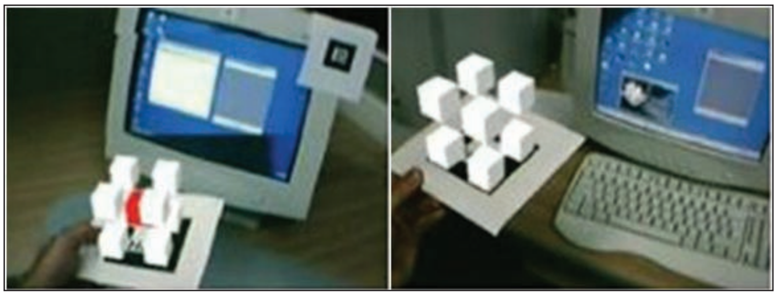
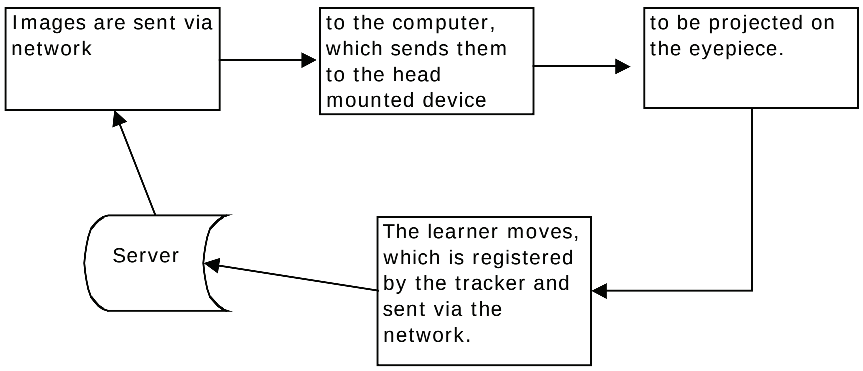


Figure 5. The integrated functions of the four technologies used in augmented reality (Copyright 2006, Katherine Ira. Reprinted with Permission.)



result from supervising a trainee learning-by-doing on the job (Traskback & Haller, 2004). The unique nature of augmented reality e-learning appears well suited for the development and practice of problem solving and physical skills (Shelton, 2002). The U.S. Naval Submarine Learning Center anticipates that the use of augmented reality in submariner training will decrease training time by 30%, decrease costs by 15%, and improve understanding (Lotring, 2006).

Researchers see a potential for augmented reality e-learning in many fields, including medicine, manufacturing and repair, architecture, paleontology, and the military (Azuma, 1997). The first successful augmented reality system was developed by Boeing to support the wiring of jets (Regenbrecht et al., 2005). While not developed as a tool for learning, it exemplifies the potential benefits of augmented reality in e-learning. Boeing wire shop workers string hundreds of miles of wiring in each plane built. As planes are customized by model, each model requires its own unique configuration of wires. A 747, for example, contains approximately 1,000 wire bundles ranging from 2–12 feet long. Wire assemblers in 1995 used customized computer printouts of formboards to guide them in stringing wire, which required constant movement between printout and plane. To increase productivity, Boeing initiated an exploratory augmented reality system to display the correct formboard image over its matching plane location. The augmented reality system has been quite effective, allowing workers to complete wiring 20–50% faster, improving productivity (Nash, 1997). Boeing's successful use of augmented reality, rapid developments in technology, and the falling costs of hardware have led to a surge in augmented reality research and development (Feiner, 2002; Kaplan-Leiserson, 2004).

Over the past decade, the U.S. military has funded much of the augmented reality research and development in the United States (Kaplan-Leiserson, 2004). One such synchronous e-learning prototype currently in development at the Naval Research Lab is Fire Support Team Training, designed to hone communication skills between the forward observer, a mortar trainee, and the Fire Direction Center. The forward observer wears a head-mounted display showing 3-dimensional virtual targets, such as combatants, tanks, and planes superimposed on the real practice range. The instructor, in the role of Fire Direction Center, uses a computer touch screen to control target movement. Looking through the head mounted display, the forward observer locates the target, identifies gird coordinates on a map, and relays the call to fire to the instructor. Once the shots are fired, the instructor determines their accuracy and effect on the target, and sends a virtual representation of that effect to the forward observer, as seen in Figure 6. The calls for fire are adjusted until the desired effect is realized. The use of wireless networking and video cameras linked to the instructor station make this augmented reality system portable, or mobile. Fire Support Team Training has been well received by mortar trainees and instructors at Quantico (Brown, Baillot, Bailey, Pfluger, Maassel, Thomas, & Julier, 2005). While a rigorous study of effectiveness has not yet been done, the ability to fire on moving targets creates a more realistic learning experience for forward observers preparing for combat.

Augmented reality is by no means limited to military applications. Mad City Murder is a collaborative, mobile, augmented reality e-learning game based on the premise that augmented reality can support content learning and development of the critical 21st century information technology skills of collaboration, information sharing, and analysis of complex information (Klopfer et al., 2005). Designed for middle school through college use, students work in teams to solve a murder mystery. Team members use a personal digital assistant with wireless Internet access and a global positioning system tracker to collect data in the field for their murder investigation (Brown, 2006). To facilitate collaboration, each team member takes a distinct role, accessing specific data unique to that role. Moving around an outdoor location, they use augmented reality to access information at specific locations and interview virtual experts, or avatars. Team members share data in the field via infrared beaming (Kleefeld, 2005). Reconvening in the classroom, students discuss and analyze information collected and formulate a hypothesis for solving the mystery.

Results indicate this is a very effective learning activity. Ten pairs of alternative high school students, described as largely unmotivated by school, actively participated, collaborated to reformulate hypotheses in the face of new data, and articulated an average of five different hypotheses in the course of the game (Academic Advanced Distributed Learning Co-Lab, n.d.). Future research will include a comparison of standardized test scores between groups of students learning with Mad City Murder Mystery and control groups learning with pen-and-paper technologies (Kleefeld, 2005).

Many augmented reality e-learning systems in research and development are applicable to workplace learning, including the Multimedia Augmented Reality Interface for E-Learning (MARIE). An outcome of the Virtual Interactive Teaching Environment, MARIE was designed to facilitate more effective learning through the use of virtual media. This system uses a lightweight head mounted display with attached camera, a computer with broadband Internet access, markers in the form of paper cards, predefined multimedia information corresponding to each marker, and a flat surfaced tabletop work area. Seated in front of a computer wearing a head mounted display, the learner is assigned a specific marker card. As the student moves the marker into the line of sight, the camera sends input to the computer, which in turn superimposes virtual 3-dimensional images and text onto the marker, as well as an animation and a 2-dimensional diagram. Figure 7 illustrates the augmented view of a learner in an engineering class (Liarokapis, Petridis, Lister, & White, 2002). This e-learning system is applicable to learning in a variety of workplace environments, including maintenance, manufacturing, architecture, and medical surgery.

A new system in development, e-AR, will blend augmented reality with an online learning management system (LMS). e-AR is designed to facilitate immersive learning and enhance remote collaboration through the use of augmented reality in a traditional e-learning environment. The prototype will feature an e-learning science course on the solar system that includes

Figure 6. Head mounted display view of a virtual target destroyed by a round of fire. From "Using Augmented Reality to Enhance Fire Support Team Training" by D. G. Brown, Y. Baillot, M. Bailey, K.C. Pfluger, P. Maassel, J. Thomas, and S.J. Julier, 2005, Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2005. (Reprinted courtesy of the U. S. Naval Research Laboratory).

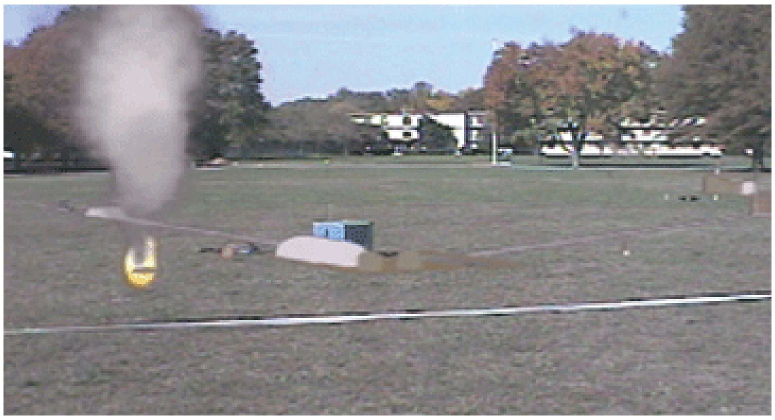
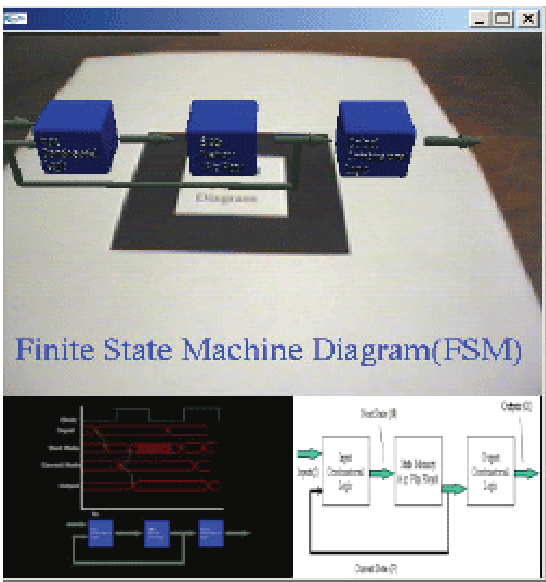


Figure 7. A MARIE user's augmented view. From "Multimedia Augmented Reality Interface for E-learning (MARIE)," by F Liarokapis, P Petridis, PF Lister, M White, 2002, World Transactions on Engineering and Technology Education 2002 UICEE, Vol.1, No.2, 2002. (Copyright 2002, Fotis Liarokapis. Used with permission.)



independent learning activities as well as synchronous collaborative activities and competitive board games. Learners will wear lightweight head mounted displays to view virtual contents stored in the learning management system, participate in synchronous events, and collaborate asynchronously to solve problems using augmented reality. Individual student progress will be monitored via the learning management system. The proposed interface features four parts: a large display area in which to view augmented reality while wearing a head mounted display; a mini-map providing special information; an area for assignments to be posted; and an area linking to online communication tools. Rigorous learner studies to evaluate the learning activities and interface design are planned for the final phase of development (Yu, 2006).

Results of a study conducted in 2002 with university students studying the solar system found that the use of augmented reality improved conceptual and factual information and led to a reduction of the misrepresentation of factual information. An interaction analysis found that learners acquired information in the augmented environment by viewing and interacting with sophisticated phenomena (Shelton, 2002). The research proposed in the e-AR study will take this a step further by analyzing learner–learner interaction as well as that of learner to content.

CONCLUSION

Augmented reality has tremendous potential for e-learning in the workplace. Its key features of interactivity, sensory immersion, mobility, and location-specific contextualization make it ideal for on-the-job learning. Availability in a traditional online course format will provide opportunities for both synchronous and asynchronous collaboration. Access to augmented reality from an online management system will make it easily accessible, on demand, to anyone with the required technology components. As technology advances, it is quite possible that all components used in augmented reality e-learning will become less cumbersome and more affordable. As research and development continue, the prediction that augmented reality e-learning will be widely available within the next decade no longer seems like a science fiction vision.

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KEY TERMS

Asynchronous: Two-way communication that does not occur simultaneously in real time, allowing people to communicate at their convenience. Examples include e-mail and discussion forums.

Augmented Reality: The overlay of computer generated images on the physical environment.

Avatar: An interactive virtual representation of a person.

Contextual Learning: Learning that takes place in a context similar to the context in which it will be applied in the real world.

E-Learning: Learning facilitated through the use of devices based on computer and communications technology such as networked computers, digital television, personal digital assistants, and mobile phones.

Global Positioning System (GPS): A worldwide system of satellites and corresponding receivers that compute physical locations on the Earth's surface. Common uses include personal tracking, navigation, and automatic vehicle location technologies.

Head Mounted Display (HMD): An optical device that displays virtual images over the real world. HMDs are often embedded in a helmet or visor.

Infrared Beaming: The use of infrared communications to send data between electronic devices.

Learning Management System: An online infrastructure platform through which learning content is organized, delivered, and managed. Features include access control, provision of learning content, communication tools, such as e-mail and threaded discussion forums, and assessment of student progress.

Local Area Network (LAN): An enclosed network connecting a collection of computers in a local area, such as an office, building, or college campus.

Marker: A physical object in augmented reality that triggers the display of predefined virtual images.

Personal Digital Assistant (PDA): Portable handheld computing device that can store, retrieve, and transmit data. Also called a palmtop, handheld computer, and pocket computer.

Situated Learning: Learning that takes place in a setting functionally identical to the setting in which it will be applied.

Synchronous: Two-way communication that occurs with no time delay, allowing interaction in real time.

Tracking Device/Tracker: Electronic device that records and/or relays information about the position and orientation of a person in motion. It can be worn by the person or attached to a stationary or moving object.

Virtual Media: The representation, effect, or essence of a real thing produced through technology.

Virtual Reality: An artificial 3-D sensory immersive environment created with computer software. The user typically wears headgear with an internal viewing screen, earphones, special gloves, and/or full-body wiring.

Wide Area Network (WAN): A group of computer networks connected together over a large geographical distance crossing metropolitan, regional, or national boundaries.

Online Trust in Mobile Commerce

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INTRODUCTION

Mobile commerce (m-commerce) has seen significant growth in the last 10 years with rapid growth in a number of areas such as mobile marketing and mobile Internet business. It has been predicted that this rapid growth will continue, with a more than doubling of users to 3.9 billion users, and 50% of the world's population, in the next five years (Worldwide Mobile Market, 2006).

In 2005, the global total number of SMS messages sent has reached 670 billion and this figure is expected to grow to 2.6 trillions by 2007 (Bauer, Barnes, Reichhardt, & Neumann, 2005). The usage of SMS business such as mobile advertising products or services is rapidly increasing. Recently reports estimated that approximately 15% of SMS global traffic would be for commercial purposes in 2004. In comparison, the m-commerce activities are more active in some of advanced countries such Finland which has reported between 50%-70% (*Finland: Mobile marketing reaches nearly half of Finns, 200*5). It has been reported that over 70% of mobile users have received mobile marketing in 2005 whereas around 10% are engaged with mobile business activities where customers who buy products via their mobile phones (PEAR, 2006, p.1). As a result, it is important to further explore strategies for implementing mobile commerce.

The aim of this study focuses solely on the customer's perceptions of the m-commerce environment, rather than on trust in intermediaries or in third parties that might mediate between the customer and the store. The focus is on development of a framework to explain m-commerce acceptance in consumers' decision-making process. The chapter further extends the technology acceptance model (TAM) in mobile commerce, particularly in the context of the consumer's confidence level in the buying decision making process, rather than only focusing on the users' acceptance of technology. The chapter provides a theoretical framework for m-commerce adoption and also suggests the important relationships between psychological and behavioral factors in the consumer decision-making process.

BACKGROUND

The m-commerce environment is more uncertain and riskier than the traditional retail environment. Since the transactions can take place without personal contact, customers are generally concerned with the legitimacy of the vendor and authenticity of the products or services. Thus, buying confidence and trust over the mobile network or Internet are major concerns. Consumer's confidence has been identified as a construct that is critical for the success of m-commerce (Steele & Tao, 2006; Tao & Steele, 2006; Torkzadeh & Dhillon, 2002), because without it, customers will not use the vendor's technology application and do business with the online mobile vendors (Reichheld & Schefter, 2000). Therefore, it is important that online mobile businesses recognize that developing customer's confidence is a key to success in m-commerce environments. As such, mobile business should continually analyze how to develop customer's confidence (Tao & Steele, 2006).

M-commerce is an extension of e-commerce. In terms of e-commerce, mobile commerce often refers to the business to consumer (B2C) model (Wong, Rubasinghe, & Steele, 2005b). In particular, Louis (2001) classified mobile B2C to include the following characteristics:

- Wireless data delivery service is a critical element of m-commerce. Popular services are weather and sports reports, traffic conditions, financial news, stock portfolio tracking, stock quotes, and telephone directory assistance.
- M-commerce transactions often require immediate actions for people on the run. For example, typical m-commerce transactions include buying

tickets, purchasing goods from vending machines via wireless devices, and trading stocks.
- M-commerce marketing functions may alert users of shops and special sales based on their locations.

There are a number of mobile technologies and applications supporting m-commerce. For example, location-based services can be used for advertising goods or services to customers in a unique way. Many innovative technologies and applications in B2C mobile commerce can be found in the retail industry (Extended Systems, 2002; Roussos, 2002; Wong et al., 2005a; Wong, Hsu, & Steele, 2005b). However, to build trust and reach customers, it is important to understand customer buying behavior such as their buying decision process.

Framework for Online Trust in Mobile Commerce

This section reviews some research streams and based on identified factors effecting confidence from the previous section, determines which ones may affect consumer buying decisions (Steele & Tao, 2006). A framework of m-commerce acceptance is proposed and discussed. A significant body of knowledge from several research streams sheds light on how confidence forms. Drawing from those theoretical streams, a number of confidence antecedents have been identified from the literature. The framework of the mobile technology acceptance model has a number of elements which are psychological and behavioral factors that effect buying behavior (see Figure 1) (Wong & Hsu, 2006). The behavioural factors include perceived ease of use and perceived usefulness (these two factors are directly adopted from TAM) (Davis, 1989). The psychological factors refer to security, convenience and trust.

Behavioral Factors

In most technological inventions, success or failure is determined by user acceptance. Attewell & Rule says it's "the pivotal factor" (Al-Gahtani, 2001). User cooperation is essential for many technology applications of mobile technology. Three important factors that lead to acceptance:

- Users have a need for increased security, and believe that the mobile technology will increase security (Wong et al., 2005a).
- Mobile technology is more convenient to use than previous/alternative systems.
- Users trust those holding the data to keep them secure and not use them in any other way than the advertised purpose.

Perceived Usefulness and Perceived Ease of Use

The technology acceptance model (TAM) is an information systems theory that models how users come to accept and use a technology. The TAM was first introduced by Davis et al. in 1986 (Davis, 1989). The model provides a traditional viewpoint about technology acceptance from users' aspects. The level of the users' acceptance depends on perceived usefulness and perceived ease of use. TAM is a well-respected model of IT adoption and use. TAM shown in Figure 2 includes two constructs; perceived usefulness and perceived ease of use (Davis, 1989).

TAM is used as a base model to produce a causal model resembling a network of relationships among the constructs of the study. This work has also indicated that perceived usefulness has the largest influence on IT acceptance followed by users' attitudes toward IT. Perceived usefulness is demonstrated to operate directly on IT acceptance and indirectly through user attitudes (Davis, 1989). Meanwhile, perceived ease of use has a larger influence on users' attitudes than perceived usefulness (Davis, 1989).

The core concept of TAM is that perceptions of usefulness, ease of use and other external variables will influence an individual's intention to use IT, which will ultimately influence actual usage behavior (Davis, 1989). The TAM also offers a promising theoretical basis for examining the factors contributing to IT acceptance in natural settings. A key purpose of TAM therefore, is to provide a basis for tracing the impact of external factors on internal beliefs and attitudes (Davis, 1989). TAM was formulated in an attempt to achieve these goals by identifying a small number of fundamental variables suggested by previous research dealing with cognitive and affective determinants of computer acceptance (Davis, Bagozzi, & Warshaw, 1989).

Perceived usefulness and perceived ease of use are the two particular beliefs, as depicted in Figure 2. According to this model, system usage is determined by the users' attitude towards using the system while at-

Figure 1. Confidence-based framework for mobile commerce adoption – An extension of the technology acceptance model (Wong & Hsu, 2006)

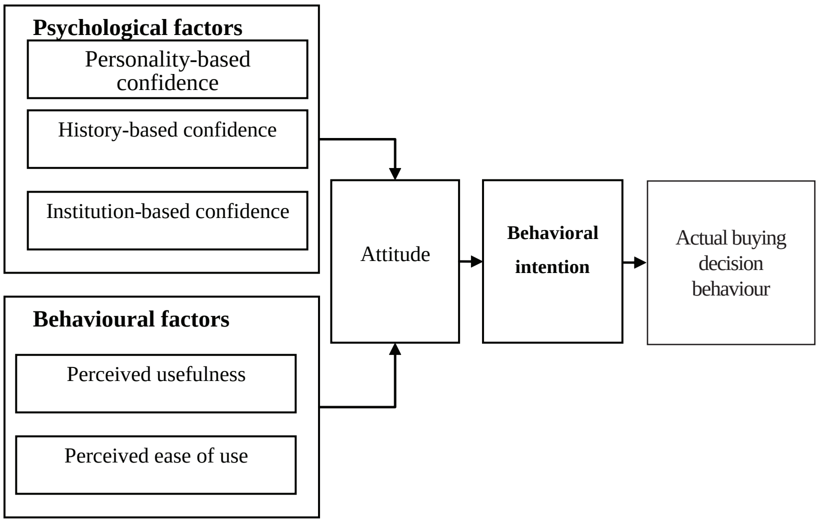
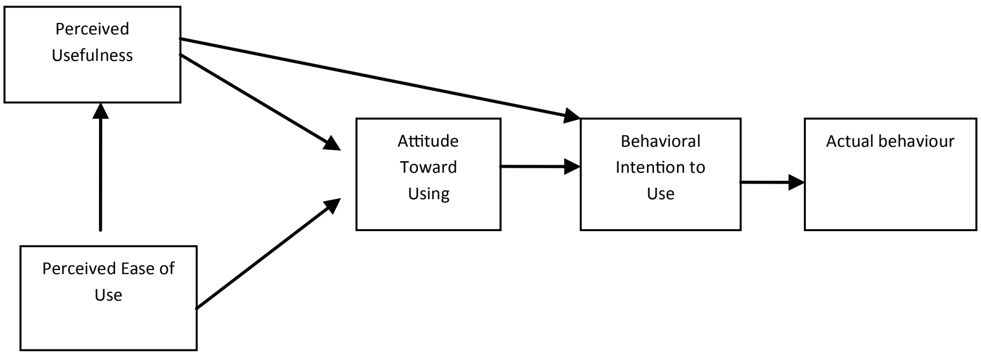


Figure 2. Technology acceptance model (Davis et al., 1989)



titude towards using is jointly determined by usefulness and ease of use (Davis, 1989). Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance performance" (Davis, 1989, p210).

Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of physical and mental efforts" (Davis, 1989, p. 320). Davis (1989) also suggested that perceived ease of use might actually be a prime causal antecedent of perceived usefulness. TAM also postulates that perceived ease of use is an important determinant of attitude toward using a system. We believe that the user friendliness of mobile devices has been a central focus in mobile technology developments over the last 20 years.

Psychological Factors

Personality-Based Confidence

Personality-based confidence is defined as the extent to which one displays a consistent tendency to be willing to depend on others across a broad spectrum of situations and persons (Mayer, Davis, & Schoorman, 1995; McKnight, Choudhury, & Kacmar, 2002). This form of confidence is based on a belief that others are typically well-meaning and reliable (Wong et al., 2005b). These beliefs are a confidence that is influenced by cultural background and personality type (Mayer et al., 1995). Such a disposition is especially important in the initial stages of a relationship (Mayer et al., 1995; McKnight, Cummings, & Chervany, 1998).

Existing researches have revealed that an individual's propensity to confidence has a relation to customer confidence in the m-commerce context. For example, research conducted by Gefen (2000) suggested that the propensity to confidence has a significant association with customer confidence. This evidence suggested that propensity to confidence should be especially important for inexperienced online mobile customers, since, in the absence of social cues and experience with an online mobile retailer, new customers are forced to base their confidence primarily on their socialized propensity to confidence (Gefen, 2000). Findings from a study carried out by Teo and Liu (2005) in U.S., Singapore, and China indicated that propensity to confidence has a positive impact on customer confidence in online purchases. Similarly, the research conducted by Wingreen and Baglione (2005) also suggested that propensity to confidence positively affects mobile confidence. However, the aforementioned studies did not take place in an Australian environment and this study seeks to verify that a propensity to confidence influences m-commerce confidence in an Australian environment.

History-Based Confidence

History-based confidence (also known as knowledge-based confidence) is based on the development of the predictability of the other party through knowing the other sufficiently well that their behavior is predictable (Lander, Purvis, McCray, & Leigh, 2004). History-based confidence relies on information rather than fear of punishment or rewards of being trustworthy. It assumes that the parties have firsthand *or* secondhand knowledge of each other, based on an interaction history and knowledge. The firsthand knowledge should come through direct familiarity with the online mobile vendor. If there is no interaction history with the particular party, Hoffman, Novak, and Peralta (1999) have noted that customers do not have confidence with most online mobile stores enough to engage in "relationship exchanges" that involve money and personal information. While the secondhand knowledge like store reputation, brand name, and store size may influence confidence, one missing factor is the implicit comfort of face-to-face communication present in firsthand interactions (Wong & Hsu, 2005). Aspects of history-based confidence such as familiarity, reputation, brand, and size will be discussed below.

History-based confidence antecedents such as familiarity with the online mobile vendor suggest that confidence develops over time with the accumulation of confidence. Thus, the development of confidence between parties requires time and an interaction history (McKnight et al., 2002). Familiarity is experience with the what, who, how, and when of what is happening. While confidence reduces social complexity relating to future activities of the other party, familiarity reduces social uncertainty through increased understanding of current actions of the store.

In m-commerce, customer familiarity, for example, corresponds to how well a customer comprehends the online procedures, including when and how to enter credit card information (Gefen, 2000). Accordingly, familiarity with an online mobile vendor should increase customer confidence because more familiarity implies an increasing amount of accumulated knowledge derived from experience from previous successful interactions through the online activities (Gefen, 2000). People tend to trust the familiar, and familiarity obtained through frequent exposure has the potential to engender confidence. Brands remain critically important to vendors (Gallaugher, 1999), since they supply three fundamental benefits. Those benefits are lower search costs, building confidence, and to communicate quality (Gallaugher, 1999). Customers feel that the better the brand is, the higher the confidence they have. Hence, the creation of better brands should produce an important source of customer confidence and so overcome their uncertainty.

Reputation is conceptualized as a customer's perception of a store's reputation, where reputation is defined as the extent to which customers believe a store is honest and concerned about its customers (Doney & Cannon, 1997). When customers do not have personal experience with a vendor, word of month reputation can be a key to attracting customers. Hearing from someone else that having a positive experience with a vendor can help ease users' perceptions of risk and insecurity in interacting with the vendor (Wong & Rubasinghe, 2005).

Doney and Canon (1997) stated that the size of a vendor is its overall size and market share position in a transitional business environment. Since a large market-share vendor should serve a more diverse and heterogeneous set of customers, research suggests that the large vendor consistently delivers on its promise to its customers and many customers tend to have confidence in it. The reasoning is that otherwise, it would not have been able to maintain its position in the industry (Doney & Canon, 1997). Large organizational size also indicates that the vendor is likely to possess expertise and necessary support systems to produce confidence and loyalty (Jarvenpaa, Tractinsky, & Vitale, 2000). In an m-commerce environment, customers consider that the large size of a vendor is able to guarantee their products or services or if a product failure or the loss of a transaction occurs the vendor can compensate buyers accordingly (Jarvenpaa et al., 2000).

Institution-Based Confidence

The concept of institution-based confidence proposed by McKnight et al. (2002) represents the beliefs held by customers about impersonal structures and favorable conditions, in which they feel safe, assured, and comfortable with the prospect of depending on the business. Although institution-based confidence considers technological components of the institution, prior theoretical (McKnight et al., 2002) and operational definitions have been very general with respect to technological factors present in the electronic marketplace (McKnight et al., 2002; Steele & Tao, 2006). The two types of institution-based confidence discussed in the literature are structural assurance and situational normality (Gefen, Karahanna, & Straub, 2003; McKnight et al., 2002).

Structural assurances or structural safeguards refer to an assessment of success due to structures such as legal recourse, guarantees, regulations, or other procedures that exist in a specific context (Gefen et al., 2003; McKnight et al., 2002). Structural assurance leads the customer to believe that it is not in the best interest of the business to defect (Doney & Cannon, 1997).

Mobile shopping also contains a level of risk (Steele & Tao, 2006). Customers cannot physically check the quality of a product or monitor the safety and security of sending sensitive personal and financial information while shopping on an electronic network (Wong et al., 2005a). This condition creates a sense of powerlessness among online mobile shoppers. Structural assurance can decrease customer risks. For example, on the Web, cues appear on the Web page, and may include seals of approval (McKnight et al., 2002), explicit privacy policy statements (McKnight et al., 2002), insurance, and affiliations, with respected companies.

As m-commerce is an innovative concept surrounded by considerable skepticism, a mobile retailer's actions must be congruent with its promises. This refers situational normality. Some researchers stated that firms could maintain customer retention by responding to service failures in a fair manner (Oliver & DeSarbo, 1988). These findings suggest that purchase intentions will remain stable, and possibly increase, when service recovery is effective. These findings imply that effective customer support also decreases customer risk and inspires confidence again. On the other hand, a poor customer service effort may substantially reduce one's future intentions to purchase from the failing firm, because the firm does not keep its promise and that dramatically reduce the confidence worthiness of the firm. In online business environments, Reibstein (2002) conducted a study over a million respondents to find out which attributes are most important in the customer choice process for the repeat buyers. His findings suggested that the highest connection falls between "perceived customer service support" and "likelihood to purchase again". Those findings implied that customer support is an important factor for customer purchase decisions in both offline and online mobile commerce. However, there is no empirical study to use customer service as a factor of measuring m-commerce confidence and this study considers that an effective customer service will affect confidence between customers and online mobile vendors (Steele & Tao, 2006).

Research on the concept of confidence in the online mobile environment, starting from the late 1990s has generated a valid list of factors that engender customer confidence in an online business environment. The commonly cited study by Hoffman et al. (1999) focuses on security and privacy as the key drivers of mobile confidence. They argue that environmental control or customer's ability to control the actions of a Web vendor directly affects customer perception of online mobile security and privacy. They also discuss the effectiveness of third-party trust-certification bodies (e.g., TRUSTe or Verisign) and the public key encryption infrastructure for ensuring transactional security (including privacy protection) as central success factors for building customer confidence in online network (Steele & Tao, 2006; Tao & Steele, 2006).

FUTURE TRENDS

The confidence-based framework for mobile commerce adoption has been described from an empirical point of view to identify which factors should be investigated in relation to m-commerce adoption. The discussion of Psychological factors from several research streams was provided above.

With personality-based confidence, new customers or inexperienced customers in the absence of social cues and experience with an online mobile store, the customer's tendency to initialize a relationship with an online mobile store is primarily based on the propensity to confidence (Gefen, 2000; Wong et al., 2005a).

With history-based confidence, consumer's confidence develops over time. Thus, the development of confidence between parties requires time and experience. Experience such as familiarity reduces social uncertainty through increased an understanding of function of the store's activity. Other antecedents in history-based confidence are reputation, brand name, and size of an online mobile store. Consumers recognize that the better reputation and brand name of an online mobile store, the more confidence worthy the online mobile store will be. Perceived size of an online mobile store was identified as an antecedent for measuring customer's confidence. However, the perceived size of an online mobile vendor does not influence customer's confidence in the same way as the perceived size of a traditional vendor does. Further, the size of an online mobile vendor is not easily or correctly judged through its technology application as in the case of a physical store. Hence, customers tend to recognize reputation and brand, and do not place much reliance on the size of an online mobile vendor unless they can know it.

Many successful methods adopted by m-commerce companies to overcome confidence barriers are institution-based confidence antecedents, reflecting that an online mobile store will perform a particular action to secure customers' feeling about their situation, guarantees and safety. Perceived security and technology application quality have some empirical support for measuring mobile confidence and most studies indicated that those two factors significantly influence mobile confidence (Wong et al., 2005b). Both perceived privacy and third-party assurance have contradictory empirical findings for measuring mobile confidence. Two other factors, insurance and customer support, have no current empirical study for measuring mobile confidence.

CONCLUSION

Focusing on online trust has been a priority and one of the primary concerns in m-commerce (Hoffman et al., 1999). As a relatively young research field, research on trust in m-commerce is still in the stage of borrowing different constructs from other theories and developing theoretical frameworks (Grabner-Krauter & Kaluscha, 2003). Grabner-Krauter and Kaluscha (2003) also noted that most researchers neglect some important factors that are relevant for trust-related behaviors.

The findings from this study reveal that to better understand consumers' assessment of online trust; it is beneficial to investigate the key factors perceived by Internet users. Inasmuch as trust develops over time and is not static but a dynamic phenomenon, this study sought to better to understand consumer's behavior from the purchase process perspective and then to identify those factors that engendered online trust. This study revealed that online vendors should focus on such online trust factors as propensity to trust, reputation, brand, system assurance, Website quality, third-party assurance, and customer service.

Most studies mainly focus on security and privacy as the key drivers of online trust (Hoffman et al., 1999; Vijayasarathy, 2004). This study provides researchers with a comprehensive framework of the factors that drive the consumer's motivation to trust an online vendor. These factors have been refined and grouped based on the trust antecedents such as personality-based trust, knowledge-based trust and institution-based trust. Seven factors in the framework should consider engendering consumer trust in the m-commerce environment.

Consumers believe that doing business with online vendors involves risk and uncertainty. Online businesses need to consider these beliefs. Several managerial implications are provided by this study. First, the issue of security is considered to be an important factor that affects consumers' purchase decisions. Online businesses have already realized secure transactions and transmission of information is an important service offered to consumers. To ensure the security of their Web sites, online vendors should develop a strict security policy and adopt appropriate security technologies. The security policy should be included as part of their Website so consumers can be reassured that the measures taken by the online vendor will protect their consumer's personal information and ensure the risk associated with unauthorized access to their information is reduced as much as possible. Hoffman et al. (1999) suggests that trust arising from privacy concerns could be accomplished better by allowing the balance of power to shift toward a more cooperative interaction between online business and its consumers. An import step in this balancing process is recognizing the consumers' right to data ownership in the Internet environment. A more customer-oriented privacy policy will lead to better relationship exchanges with important benefits for the consumers and online vendors. By disclosing on the Website, the online vendor's privacy practices, consumers' privacy concerns should significantly decrease and online vendors can build a more trusting environment for online transactions.

Second, third-party assurance can be treated as an important signal or argument for the development of online trust in the m-commerce context. However, third-party assurance may useless when consumers are unfamiliar with the third-party assurors provide or when they do not comprehend the meaning of such assurances as displaying a Web seal (Moores, 2005). In order to increase consumers' online trust, Internet vendors should participate in recognized and trustworthy third-party assurance programs and endeavor to educate consumers about the significance of the third-party assurance. Consumers who aware of and have knowledge about Web seals will perceive that transacting with Internet vendor is assured, and thus will exhibit higher trust (De Ruyter, Wetzels, & Kleijnen, 2001).

Third, a high-quality and well-designed Website is also critical when consumers consider transacting with online vendors (Grabner-Krauter & Kaluscha, 2003). A consumer usually can efficiently search and collect enough product information over the Internet when the customer is considering buying a product or service. In searching for information, abundant information may lead to information anxiety. Further, not all information will be useful for purchase decision making. However, information that is unclear or confusing will increase uncertainty and risk and may result in consumers' reluctance to purchase products over the Internet. Thus, online vendors should provide appropriate key product information on their Website in order to lower consumers' perceived uncertainty about shopping on their Web sites. A high-quality and well-designed Web site can be employed to predict the shopping results, thus engendering trust toward an online vendor.

Fourth, online customer service can be improved through the introduction of comprehensive electronic tools and technologies. For example, online vendors provide the tracking system that integrates logistics with global positioning system (GPS) and then consumers can know their product shopping status with an easy click. Service supported by appropriate electronic technology is essential to improve operational efficiencies and maintain consumer satisfaction. Thus, online businesses can offer excellent customer service and create positive customer experience through order processing, payment integration, on time delivery and after-sales service.

Finally, the literature has shown that the perceived reputation of online vendor is related to online trust. This relationship was also shown in this study, since reputation and online trust loaded on the same factor. Online business should have a good reputation in the market to continue growth in the m-commerce environment. It is recommended that regular advertising and marketing campaigns in various communication channels will enhance perceived reputation of online vendor (Papadopoulou et al., 2001).

Rapid developments in technology have made significant contributions to secure the network for m-commerce. However, challenges remain in this area, and consumer confidence remains a substantial issue for the development of m-commerce. Many other researchers have reinforced this belief asserting that only after security and privacy have been addressed will customers consider other features (i.e., familiarity, reputation, technology application quality) to determine the extent to which they can have confidence and feel safe transacting with a merchant. This chapter overviewed important factors in m-commerce acceptance both behavioral and psychological. To examine customer acceptance of mobile commerce, we have applied and extended the TAM. The confidence-based framework for B2C mobile commerce has been developed for empirical validation of the research problems.

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KEY TERMS

History-Based Confidence: History-based confidence (also known as knowledge-based confidence) is based on the development of the predictability of the other party through knowing the other sufficiently well that their behavior is predictable.

Institution-Based Confidence: The concept of institution-based confidence proposed by McKnight et al. (2002) represents the beliefs held by customers about impersonal structures and favorable conditions, in which they feel safe, assured, and comfortable with the prospect of depending on the business.

Mobile Commerce (M-Commerce): M-commerce is an extension of e-commerce. In terms of e-commerce, mobile commerce often refers to the business to consumer (B2C) model.

Personality-Based Confidence: Personality-based confidence is defined as the extent to which one displays a consistent tendency to be willing to depend on others across a broad spectrum of situations and persons.

Structural Assurances: Structural assurances or structural safeguards refer to an assessment of success due to structures such as legal recourse, guarantees, regulations, or other procedures that exist in a specific context.

Technology Acceptance Model (TAM): The TAM is an information systems theory that models how users come to accept and use a technology. The TAM was first introduced by Davis et al. in 1986 (Davis, 1989). The model provides a traditional view point about technology acceptance from users' aspects.

The Open Catalogue of Manuscripts in the Malatestiana Library

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INTRODUCTION

Many experiences laying on the Internet use have been carried out in Paleography during last years and radical changes in the methods usually adopted in that discipline have been introduced. Furthermore specially planned information systems for bibliographical data management are more and more used and are influencing everyday work and study processes.

In the authors' opinion the proposal for the introduction of special information systems and especially of the Open Catalogue of manuscripts have their roots in the revision of Paleography research and study methods, in the connections the discipline will settle with other sciences (i.e., IS, IT and ICT disciplines) and in the creation of new roles for the users of the information the discipline will produce.

Is There the Need for a Revision of Paleography Research Methods and Instruments?

ICT radically changed the approach scholars had with manuscripts for at least two reasons:

a. The way manuscripts were analyzed; researchers had in fact to personally study manuscripts in archives or libraries
b. The medium the members of the scientific community adopted until now to share the results of their work; it was in fact based on a printed Catalogue (i.e., printed matter that acquires its definite form and scientific value only when it is published)

During last years the spreading of networking communication techniques produced relevant effects on the sharing of knowledge and information also within the community of the paleographers and of the scholars involved in manuscripts' analysis and study. First of all the Web was used to publish the images reproducing manuscripts pages, but there were also experiences concerning on line historical magazines, collections of bibliographies, or special databases on copyists and manuscripts (Cartelli, Miglio, & Palma, 2001).

The considerations and the proposals coming from newly defined disciplines like informing science (Cohen, 1999), led the authors to the definition of a special information system called "Open Catalogue". This system, which is described in the following section, has been adopted and carried out from the staff of the Malatestiana Library, an ancient Italian library hosting a consistent number of manuscripts.

Catalogues of Manuscripts and the Open Catalogue

The history of manuscript cataloguing began between 17th and 18th century, when some scholars (Peter Lambeck in Vienna, Bernard de Montfaucon in Paris) prepared the first printed catalogues of manuscript collections. Their example was followed in the last two centuries by many cataloguers, who described thousands of manuscripts written in ancient and modern languages stored in many big and small libraries throughout Europe and the rest of the Western world. Notwithstanding the great work paleographers made in these centuries an enormous amount of manuscripts still remains uncatalogued, if not unknown.

The main trouble with old, handwritten books is the difficulty of getting in touch with them, mostly for the following reasons:

a. People simply do not know of manuscripts' existence in a given place (with respect to texts, where bibliographies and Internet resources make relatively easy to find a printed book, or at least a bibliographical description of its content, the same instruments are usually not available for manuscripts),
b. Every manuscript is a unique book: there are no duplicates for it. Even if the text in two books is the same, as in the case of a model and its copy, the two books can be different in script, physical appearance and even text, because a handwritten copy always contains some changes with respect to its source. This is the main reason for an accurate description of the external and internal features of every single handwritten book: to identify and qualify it beyond its sheer shelf mark, that is, what for a human being is her or his name.

Due to the features of a manuscript (physical appearance, materials making it, number of folios, content organization, presence or not of illuminations, etc.) a catalogue of manuscripts is a really difficult task, it requires a deep competence in a lot of fields, from philology to history, from history of art to paleography, from literature to library science. A catalogue of medieval (or modern) manuscripts can then be carried out by connoisseurs who devote an enormous amount of time and work to describe some tens or hundreds of these peculiar objects which lie hidden in the shelves of libraries, normally accessible only to the few scholars who are admitted to their direct study.

It is easily understandable how and why in the last decades many librarians or researchers liked much to write books about the theory of manuscript description than prepare catalogues of manuscripts.

In the authors' opinion time has come for a radical change in catalogue publishing. First of all the Internet can make available great part of the manuscript heritage all over the world (i.e., a good example for the new way of catalogues' publishing can be found in what is reported from CDF and Overgaauw, 2001, in Germany); furthermore it is possible to give scholars new and more powerful tools to improve their work and let them create *Open Catalogues* (i.e., catalogues in progress, constantly changing with the continuous contribution of new information).

The Open Catalogue of Manuscripts

The project of the information system to be used for the O*pen Catalogue* had to take into the right consideration the communication medium it was based on, that is, the Internet. The creation of a Web site looked very soon as the best solution for an on line community within which people could meet other people or share their researches and ideas; the site was also helped in the management of manuscripts' data by a database. The whole system looked reliable enough both on the server side and on the client side; in the first case the reliability laid on the server technical features (its fault tolerance, backup procedures, etc.) and on the Net steadiness (nowadays only seldom happen breakdowns preventing people from the use of connecting services), in the second case the clients connecting features seemed to guarantee a good and easy access to Web resources. In both cases the property rights of the information made available on the Net was reasonably guaranteed.

While planning the structure of the Open Catalogue the following environments were kept apart (Cartelli & Palma, 2002): a former one where researchers and scholars had the scientific liability of the materials to be published and a latter one people could use occasionally or systematically to obtain information (i.e., not to produce them).

The separation affected the way users could access the system and led to three different and separated access levels:

a. System and scientific administrator level; one or more persons having the scientific responsibility of the catalogue, who can enable researchers and scholars to enter into the system and give them the access rights to manage the materials to be published; at this level it is also possible the management of the data produced by everyone
b. Scholars and researchers level; allowed people who can insert, modify, delete and display the materials to be published (manuscripts' descriptions, notes, images, etc.), at least when they decide that the materials have an ultimate structure and can be publicly accessed
c. General user level, where only the answers to specific queries can be obtained (i.e., the descriptions and images of manuscripts, notes, etc.).

As regards the structure of the Open Catalogue it was hypothesized to be made of five sections, to be intended in a flexible manner, that is, the presence of each section depends on the resources the library will have at its disposal and on the different solutions it will adopt (Cartelli & Palma, 2003):

a. The first section is devoted to documents explaining the history of the library and its manuscripts;
b. The bibliography ordered by shelfmark and, eventually, alphabetically and chronologically, is housed in the second section;
c. In the third section the descriptions of the manuscripts, that is, previous printed catalogues or ancient handwritten catalogues (suitably digitized) and new descriptions (according to nationally/internationally defined standards) are stored;
d. The fourth section is devoted to the images of the highest number of manuscripts in the library (possibly all);
e. The fifth and last section is based on a communication subsystem including electronic blackboards, chats, forums and special Web solutions granting the easier acquisition, writing and editing of texts among the members of a selected community of scholars interested in the materials of the library.

MALATESTIANA LIBRARY AND THE OPEN CATALOGUE OF MANUSCRIPTS

In the *libraria* designed and built in the mid-15th century by Malatesta Novello, Lord of Cesena, 343 manuscripts, which give witness to his tastes and cultural inclinations, are housed. Malatesta Novello enriched the ancient volumes (about 50) of the Franciscan convent with an invaluable collection of manuscripts which were especially copied and illuminated, and with the codices which were purchased, received in donation, dedicated, or already part of his family's patrimony. The collection of Giovanni di Marco, the physician of Malatesta Novello, is made of 53 codices that were added to this already noteworthy and homogenous collection. Few later donations on behalf of the citizens of Cesena have not altered the original characteristics of this quite impressive collection of ancient books.

Moreover, the Malatestiana Library houses two celebrated 15th century liturgical series consisting in seven choral books of the Cathedral and eight other books of the Franciscan convent. These works can be traced back to the project aimed at bibliographic renewal undertaken by Malatesta Novello. Finally, 59 manuscripts spanning from the 12th to the 15th century belong to the Piana Library, which was the private library of Pope Pius VII (Barnaba Chiaramonti). Twelve more manuscripts belonged to the town library, which was formed at the beginning of the 19th century with the books once in the property of the dissolved religious houses. The total number of manuscripts is made of 429 specimens.

Over the years, significant and in-depth studies have enriched, renewed and updated the traditional printed catalogues by Giuseppe Maria Muccioli and Raimondo Zazzeri, starting from the fundamental contributions of Augusto Campana up to the research done in the last twenty years.

The staff of the Malatestiana Library supported the idea of the Open Catalogue and decided to find the resources for building it mostly because it looked interesting and useful to have a *catalogue in progress*. The advantages of this choice were both immediate and evident:

- The possibility of proceeding in a programmed and gradual manner;
- The ability to retrieve all the information already

acquired even in a partial and non-final form;
- The opportunity to extend the research to ancient sources that were difficult to access;
- The increase in the interactive updating of the information available by qualified specialists and scholars.

The Website for the Open Catalogue of manuscripts in the Malatestiana Library can be accessed from the portal of the Forlì-Cesena county, with a direct access from the new Library Web page (http://www.malatestiana.it/manoscritti/). The database accompanying the site was autonomously constructed with a personalized wwwisis 5.0 application.

The catalogue is made of four parts:

- The first part credits people working to the project and its carrying out,
- The second section contains general texts on the Library and the manuscript collections (i.e., history of the library, Cesena humanistic culture, the scriptorium, the illumination, the collections, etc.); first of all classical texts suitably digitized have been put on line, special works and degree theses are adding to the former ones together with descriptions of the Library coming from foreign visitors,
- The third part provides a list of all the manuscripts according to shelf mark, although manuscripts can also be accessed by author and title. For each codex there is its description according to the two traditional catalogues by Muccioli and Zazzeri, all the complete or partial descriptions taken from existing catalogues and the bibliography. The bibliography on each manuscript is furnished on the basis of the traditional catalogues and the more recent studies. A program for a regular updating and retrieval of recent and previous bibliography, according to the resources of the Malatestiana Library and its goals has been planned. At the moment users will find in this section the reproductions of 76 codices, although the Library plans to offer a complete reproduction of all the manuscripts;
- The fourth section plays a fundamental role in this project hosting users' requests, opinions and articles. Here, scholars or persons interested in the Library's manuscript collection can contribute with their observations, as well as publish their contributions online. Recently this section enriched of two special functionalities:

  a. collaborative bibliography, by which everyone entrusted with the access to the section can insert a personal bibliographical record in the page,
  b. manuscript's work in progress, by which a community of study and research is granted permission of accessing all the texts in the area.

The open catalogue neither excludes nor acts as a supplementary to a printed work, which is always possible and even desirable, because this has a particular type of diffusion and is permanent by nature. Instead, the open catalogue is updated constantly by the Library staff, particularly by those who are involved in manuscript preservation. It is their duty to actively administrate the site and to promote research even encouraging interested specialists to provide critical contributions.

Figure 1 reports the home page of the manuscripts' section of the Malatestiana Library (i.e., the Open Catalogue).

CONCLUSION AND FUTURE TRENDS

Main remarks on the work carried out from Malatestiana staff during last three years can be easily summarized as follows (Cartelli & Palma, 2007):

- Institutional librarians not only coordinated the work in the library and in the site but also produced descriptions and bibliographies for the manuscripts (until now 76 manuscripts have been reproduced and made available in the library site),
- Continuous contacts have been kept with public and private institutions and with scholars interested in the study of manuscripts in the Malatestiana library,
- Young and highly qualified people (i.e., people coming from special humanistic studies) has been involved in the production of manuscripts' descriptions and other texts.

Figure 1. Home page of the Open Catalogue of Manuscripts in Malatestiana Library

Furthermore, the use of Web technologies produced relevant effects on the way of studying and working in this field by introducing social-constructivist elements in everyday activities. In other words it became possible the sharing of knowledge and experiences on manuscripts' analysis and study never known before.

What will happen in the future? When all the manuscripts in the library will be digitized and will be on line the work of the librarians will be at the end? The answer can only be negative for different reasons. First of all there will be the need for the updating of the bibliography, secondly new kinds of cooperation and sharing among scientists and scholars can be hypothesized while new types of involvement in library work for general users of its information can be planned.

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KEYWORDS

Catalogue: Usually been a book describing one or more ancient manuscripts or books (hosted or not in the same library but having some common feature). The Internet, and especially the Web, have changed the way of cataloguing manuscripts and new ways of making available their information are today possible. The Open Catalogue of manuscripts is the solution adopted from the Malatestiana Library in Cesena and from the Lancisiana Library in Rome.

Codicology: The discipline studying the structure of ancient manuscripts from binding to pages' materials (parchment or paper) and structure till illuminations; it also studies the arrangement of the text within the pages. During last decades together with the qualitative description of the codices their quantitative study affirmed and is today a solid branch of the discipline.

Information System: The whole set of persons, data records, and activities that process information in a given organization. It includes manual processes and automated processes. Recently the definition has been erroneously used as a synonymous for computer-based information system, where only the technological component of an information system is included.

Manuscript: A book handwritten by a copyist on parchment or paper. Manuscripts were especially used in the Middle Ages before printing invention and every manuscript is unique because there are no duplicates for it. Even if the text in two books is the same, as in the case of a model and its copy, the two books can be different in script, physical appearance and even text, because a handwritten copy always contains some changes with respect to its source.

Open Catalogue: The answer to the need of spreading information on manuscripts and ancient books in the knowledge society. It intensively uses IT and ICT and is mostly based on an information system which can be differently accessed from various kinds of people. It aims at the joint management of information storing and retrieving while creating a sort of "virtual library".

Paleography: The discipline studying ancient writing styles and their evolution during the centuries. It can be defined a cross-discipline because it needs deep competences from a lot of fields: Greek and Latin ancient languages, philology, history and literature only to cite some among them.

Web Technologies: A very general definition including both the basic instruments for the creation of dynamic Web sites (Web server software, interface language, database instruments) and the instruments marking the evolution of the Web towards Web 2.0 (social-networking sites, wikis and folksonomies) and Web 3.0 (Semantic Web, Geospatial Web or 3D Web).

An Overview of Online Trust Derivatives for E-Commerce Adoption

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INTRODUCTION

With the growing share of electronic commerce in the global economy, distance trust building has become imperative; as a result better models to evaluate, represent, and transfer online trust are required for wider adoption of electronic commerce. Emerging and small electronic merchants, who do not have established brand value, employ a number of techniques to transfer trust from different sources. Trust is a significant stumbling block in the development and wide adoption of electronic commerce. When physically present established merchants enter into e-business environment they face none or little restrictions in capturing online consumer market, primarily because of the trust value already associated with their brand. The total trust value of any merchant is composite of individual and collective trust transfers. In relation to established e-merchants, establishing e-merchants have to heavily rely on different individual and collective trust transferring techniques.

This chapter identifies various individual and collective online trust transferring techniques that e-merchants can employ for their business growth. The individual sources include, Web user interface, provision of alternate dispute resolution, and availability of transaction insurance. The collective online trust transferring derivatives include trusted referrals, online reputation and use of privacy and security seals.

In the next section an overview of each technique is presented. Followed by the overview, a conceptual model is presented which outlines the impact of each trust transferring source on different dynamics of e-business and each dynamic's characteristics. The proposed model targets to assist the e-businesses to select a right combination of trust derivatives. Further assisting the e businesses in enhancing their brand value based on the behavior of their potential customer base.

ONLINE TRUST TRANSFERRING TECHNIQUES

Individual and collective trust transferring practices are the two groups of techniques that can be employed by e-merchants to enhance users trust on them. The recognized techniques are discussed below.

Collective Trust Transferring Techniques

Collective trust transferring techniques rely on combined effort of several users and service providers. Such techniques have much wider impact on potential customers. The recognised collective transferring derivatives are discussed below.

a. **Trusted referral:** Information regarding a product, physical or online business acquired from either the user's physical, or online trusted social network impacts the user's initial and subsequent levels of trust in an online business. The impact is directly associated with the user's level of trust on the source of information in terms of its credibility, honesty, and ability. Trusted referrals (Kim & Prabhakar, 2000) "are the primary means of disseminating market information when the services are particularly complex and difficult to evaluate. This implies that if one gets positive word-of-mouth referrals on e-commerce from a person with strong personal ties, the consumer may establish higher levels of initial trust in e-commerce" (p. 538). Fullam and Barber (2004) pointed out that the user's belief on information accuracy and certainty conveyed in the information, form the level of trust in the information source. Thus one may conclude that 'a referral from the user's personal trusted source actually transfers trust from the referring source to the referred entity.'

While analysing the impact of trusted referrals Fullam et al. identified that users' prior confidence in the information source that is, users' perceived trustworthiness of the information source, contents of the reported information, number of sources reporting similar information, certainty conveyed in the information and age of the information affect the users' belief on acquired information. Besides aforemetioned factors, the existence of trusted referrals in small isolated segments, if any, is an obstacle limiting the capability of new and emerging merchants to fully utilize their business potential. Any new and emerging online merchant will have relatively lower brand value and small existing customer base in relation to established existing e-merchants. Therefore they have to rely more on other individual and collective trust transferring sources to further increase potential customers' trust in them.

b. **Online reputation:** In the absence of trusted referral, online reputation is one of the main sources used by customers to establish relations with online service providers. Zacharia (1999) states "reputation is usually defined as the amount of trust inspired by a particular person in a specific setting or domain of interest" (p. 163). Online reputation regarding an e-business is built by collating the past experiences of the users who have previously interacted with the same service provider. This technique in the form of reviews, feedback and point ratings, is also used by several online auction sites like eBay.com and some Web retailers like Amazon.com to enhance user's level of trust in Web merchants. In an empirical study by Sarah, Choon-Ling, and Kai (2002) it was identified that most users give high value to the previous customers' endorsements to evaluate the ability of the Web merchant, even more than third party affiliation. In the study 80% of the respondents reacted positively to establishing trust on online merchant, due to the positive feedback from the previous customers.

Resnick, Zeckhauser, Friedman, and Kuwabara (2000) identified that, from potential customer's perspective, the absence of a process to validate and assure the honesty of feedbacks, acts as a hurdle in wide acceptance of the online reputation system. In the same study, the absence of a mechanism to exchange/share online feedback information between reputation systems was identified as an effectiveness limiting factor of such systems. This lack of inter-integration makes the collection of information from all trusted sources expensive and a tiring activity for the potential customers. Resnick et al. (2000) also recognized that mostly previous customers do not bother to provide any feedback and if they do, they usually only provide feedback if they go through very bad experience.

Moreover the new and emerging online merchants have relatively small existing customer base, therefore they cannot fully rely on online reputations systems to build trust. Thus online reputation building should be a parallel process which the e-merchants should execute as they establish their brand and online business.

c. **Third party privacy and security seals:** Third party Web seals are used to provide consumers with a trusted view of an e-merchant. Such seals are mostly used by new and small businesses. The dominant trust seals used on the Internet include BBBOnLine Privacy (2006a), BBBOnline Reliability (2006b), TRUSTe (2006), and WebTrust. While evaluating the impact of WebTrust (2006) on users perceived trustworthiness Portz (2000) identified that 94% of the participants noticed the presence of WebTrust seal. A recent study by Egger (2003) identified that the Web-based trust seals contribute significantly to trustworthiness in case of US respondents. The same study recognized that Americans consider the presence of familiar brands and credit card companies' logos, like MasterCard or Visa, as less of an indication of trustworthiness than Web-only trusted third parties like VeriSign or TRUSTe. Cheskin Research (2000) investigated the international validity of online seals. Cheskin research concluded that the VISA brand is most trusted in Latin America while TRUSTe is most trusted in US. However contrary to other studies, Princeton Survey Research Associates (2002) survey estimated that only 19% of respondents identified seals as important factor in their trust formation.

The third party seals are mostly used by new or small businesses, as it only makes sense to use them when the trust value generated by the seals used on the Website exceeds the trust value generated by the merchant's brand. This explains why major e-brands are not part of online seal programs. McKnight, Choudhury, and Kacmar (2000) while evaluating the effectiveness of trusted third part seals and icons in promoting consumer trust in electronic commerce states that "Web-related consumer decisions take place within the context of an individual's personal tendencies and his/her perceptions about the web environment. Thus, user trust in web vendors and the effect of third party icons may depend, to an extent, on individual characteristics … and an individual's prior experience with the web". A recent study by Egger (2003) identified that Web-only privacy and security seals were perceived as trustworthy only by the people who know them. Burke, Kovar, and Kovar (2000) study identified that consumers who attended to the seal, were those who were exposed to the advertisement about the seal.

Individual Trust Transferring Techniques

The commonly used trust transfer techniques include, Web interface design, use of privacy policies, availability of transaction insurance and alternate dispute resolution. The individual techniques are subjective and are impacted by users' cultural background, physical and social context and personal experiences.

a. **Web interface:** The impact of Web site interface and its structure has been studied in detail by many researchers. Effective interface, good quality graphics and ease of use have been recognised to portray trustworthiness (Kubilus, 2000). Jarvenpaa, Tractinsky, and Saarinen (1999) believe that trustworthiness features of a Website actually function as an expert and professional salesperson of the company. The relationship between Website interface and consumer decision was also identified by Karvonen (Karvonen, 2000, 2001). In another study Karvonen and Parkkinen (2001) suggested the use of real pictures rather than abstract graphics to further enhance users' trust. Basso, Goldberg, Greenspan, and Weimer (2001) while analysing the emotional and cognitive factors underlying judgments of trust in e-commerce indicated that Web retailers actually use eye-catching graphics to convey competence and professionalism along with an attempt to grab user's attention. The strong relationship between Website quality and users' initial trust is also empirically verified by Kim and Tadisina (2005). Head, Hassanein, and Cho (2003) also identified a strong positive relationship between Web interface and product trust and company trust.

b. **Alternate dispute resolution:** Access to alternate dispute resolution is one of the emerging techniques employed by e-businesses to enhance users' trust in electronic transactions and environment. Due to costs involved with the traditional legal system in terms of time, effort and money, the availability of alternate dispute resolution is considered to be an impacting factor in user's final decision. Such services are usually provided as an added facility by the electronic service providers either for very little fee or in some cases free of charge. The effectiveness of such systems is yet to be empirically tested.

c. **Privacy statement:** Online privacy is information privacy in the electronic environment, mostly over the internet. Chellappa (2002) defined online privacy as "… an individual's ability to control the terms by which their personal information is acquired and used" (p. 10). Culnan and Armstrong (1999) established that consumers do not hesitate to provide personal information, if they expect to get benefit from it. The same study concluded that most consumers will provide personal information if they believe that they have control over the provided personal information. Although online consumers are willing to provide their personal information for personal gains, the risks associated with information disclosure to third parties without the user's explicit consent does add to the total risk factor. Therefore the presence of a clear privacy statement does add value to users' trust in online business.

d. **Online security technology:** Environmental uncertainty is negatively influenced by the behaviour of Web retailers who aim to reduce infrastructure-related concerns. In Benassi's (1999) observation the user's level of trust in infrastructure can be greatly increased by facilitating encrypted transactions, installing firewalls, utilizing authentication mechanisms, and ensuring privacy seals and providing disclosure statements. Even though trust building is more than secure communication via electronic networks, as the reliability of information regarding the trade partner has little to do with secure communication and more to do with variables which enhance the user's trust level in e-business in terms of business's performance, credibility and ability to perform the designated task. But the provision of secure environment and communication channel does transfer user's trust in security technology to the online business.

Trust Derivatives, Business Dimensions, and Characteristics

The proposed conceptual model presents the three dimensions of e-business consisting of business performance, business worthiness and financial transaction. These are the main components of e-business that impact most the potential customers in an electronic environment while committing a transaction.

a. **Business performance:** Business performance is the business's ability to process and deliver orders. Customers trust in business performance can be enhanced through trust transfers from e-business's online reputation, trusted referral(s) and the interface of the Website. It is suggested there that any trust derived to business performance will actually result in increased user's trust in business capability and ability to execute and fulfil the submitted order.
b. **Business worthiness:** Business worthiness is e-merchant's ability to reliably deliver the ordered product or service as per specifications and handle customers' information with credibility and honesty. Customers' trust in business worthiness can be enhanced through trust transfers from trusted referrals and presence of privacy statements and seals. It is proposed here that any trust derived from business worthiness impacts user's trust in business reliability in terms of meeting the order requirements and utilizing the user's personal information in an ethical and professional manner.
c. **Transaction insurance:** Due to the gap in exchange of funds and delivery of goods and services in electronic environment, user's perceived trust on e-transaction is one of the important contributing factors. The use of proper online security technologies, provision of alternate dispute resolution services and availability of transaction insurance are the primary sources for transferring trust to further improve user's trust in financial transaction. The enhanced user's trust on financial transaction increases user's trust on transaction medium and actual exchange of funds.

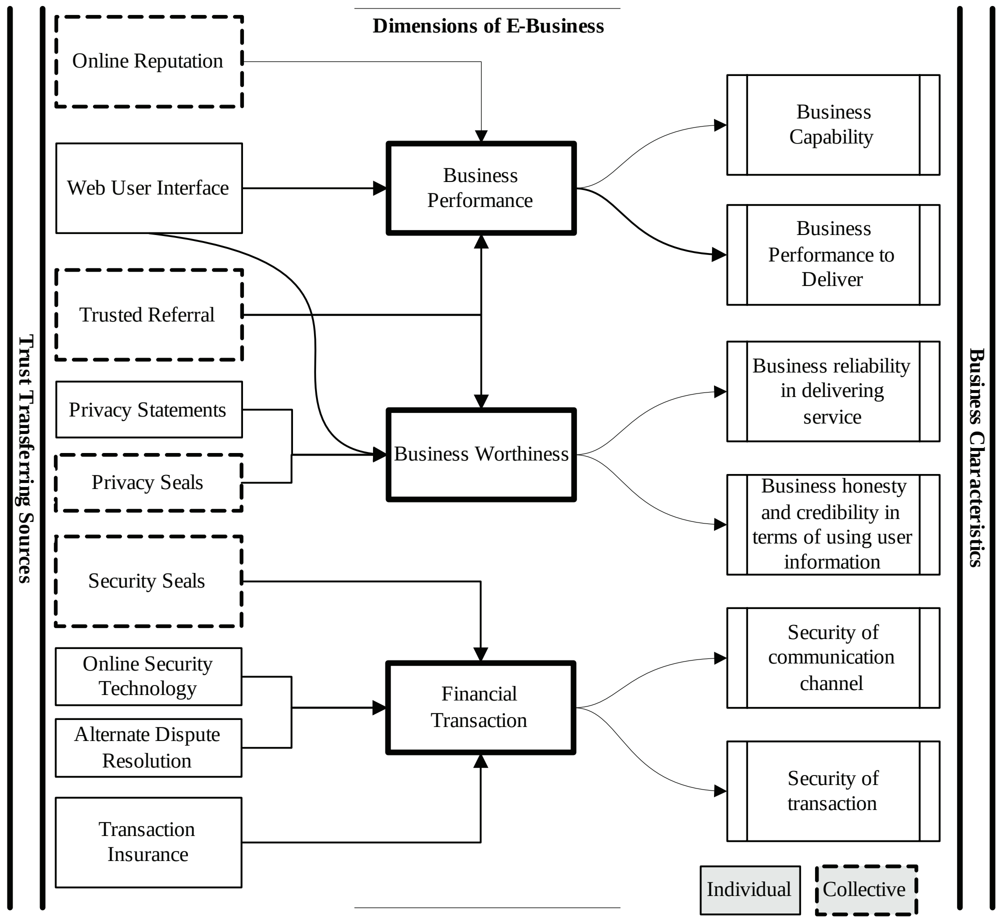
The recognised collective and individual e-trust derivatives, their effect on e-business dimensions and each dimension's characteristics are presented in Figure 1.

FUTURE DIRECTIONS

It is expected that, in future, the users will rely more on trusted electronic social networks. Such online networks will be built by using Web 2.0 technologies such as, Atom, RDF and "Friend of a Friend" (FOAF) (Bricklety & Miller, 2005). Such technologies will aim for social integration, user-contributed contents, user-generated metadata, transparent business processes and decentralized and participatory products and processes (Gartner, 2006a). It is expected that the users will use such open and non-proprietary technologies to add contents for collective intelligence. And businesses will make use of such networks and contributions to promote and establish their brand in the electronic environment. Due to the open and non-proprietary nature of such technologies, the Web 2.0 applications will be able to automatically process gathered information from varied sources such as customers' reviews regarding a particular business etc. Such applications are also likely to use mathematical models to collect, process and represent other customers' trust evaluations regarding e-businesses (Mahmood, in press).

E-businesses are also likely to make use of trust enhancing models to increase the potential customers' general level of trust and to get more market share. For example, Mahmood proposed models that can be used by online merchants to recognize and target specific characteristics of their Website which impact most in determining the user's level of trust (Mahmood, in press; Mahmood, in press). In future, trust based online merchant independent rating systems, trusted peer to peer networks and personal electronic social networks will be widely used by users and businesses to transfer trust for competitive advantage.

Figure 1. Linking trust derivatives with business dimensions and characteristics



CONCLUSION

Trust plays pivotal role in the development and wide adoption of electronic commerce. Established brands and companies are always at advantage to capture relatively more share of the physical and electronic markets, due to their higher brand value and existing customer base. Companies that are new in e-market and do not have existing customer base rely on collective and individual techniques to derive trust from different sources. Such techniques are used to boost their brand value for competitive business advantage. This chapter provides an overview, limitations, and advantages of recognized collective and individual trust transferring derivatives (techniques – sources). The proposed model outlines the effects of e-trust derivatives on e-business dimensions. Each business dimensions' characteristics are also presented in the model. The model presents the recognized links between the transferred trust from different sources on different dimensions of e-business and their individual characteristic. It aims to assist the e-businesses to select the right combination of trust derivatives to enhance their brand value

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KEYWORDS

Collective Trust Transfer: Collective trust transferring techniques rely on combined effort of several users, service providers, and communities. Such techniques have much wider impact on potential customers, as they involve large number of contributing parties and are widely available.

Online Reputation: Online reputation is the online information regarding an e-business from the past direct or indirect experiences of a large body of users. It is the general opinion of the users toward a person, a group of people, or an organization in the cyberspace.

Privacy Statement: Privacy statement is a statement posted on the company's or individual's Website that explains the personal information being collected with or without a visitor's consent, the reasons it is being collected, and how the collected information will be used or shared. The privacy statement also states that how the information provided by someone else is used and shared.

Trust: Trust is the subjective estimation by which an individual, A, estimates about how likely another individual, B, performs a given task on which the subject's welfare (interests) depends. It also consists of the elements of dependence, competence, disposition, and fulfillment.

Trusted Referral: Trusted referral is the information regarding a product or physical or online business, service or individual acquired from either the user's physical or online trusted network. It impacts the user's initial and subsequent levels of trust in an online business. The impact is directly related to the user's level of trust on the source in terms of source's credibility, honesty and ability.

Web 2.0: Web 2.0 is a network platform, enabling the utilization of distributed services such as social networking and communication tools. It is also referred as the architecture of participation.

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A Participatory Design Project on Mobile ICT

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INTRODUCTION

Statistical data on employees in Europe indicate the increased prevalence of new types of work and organisations (Lilischkis, 2003; Lilischkis & Meyer, 2003). There is a lot of quantitative evidence of the spread of mobile e-work. SIBIS (2002/2003) defines mobile workers as those who spend some working time away from their home or workplace such as on business trips, in the field, or on customer's premises. High intensity mobile workers are those who work in a remote location at least 10 hours in a week. Mobile e-work is defined as high intensity mobile work in the course of which an online connection to the Internet and to company computer systems is used. User-oriented information and communication technology (ICT) facilitates, enables, and supports mobile work and workers.

Useful communication and collaboration tools are a prerequisite for effective e-work. However, the usability and reliability of the tools also affect the functioning and well-being of the dispersed mobile group, as well as the individual worker's well-being (Hyrkkänen, 2006; Richter, Meyer, & Sommer, 2006; Vartiainen, Hakonen, & Kokko, 2003). In developing user-oriented communication and collaboration equipment, much attention has been paid to the tools themselves. On the other hand, the fact that the development of new electronic tools challenges the development of the entire work activity system has received little attention.

When a newly developed tool is launched, the old and new practices collide and a number of conflicts emerge. In the worst case, this leads employees to spend their time resisting the change. Tool development should be expanded to include working concepts in which attention is paid to developing the entire work activity system (Carayon, 2006; Engeström, 2006). In this case, it is important to get the users to take part in the new tool development. Then errors and misunderstandings in user-designer collaboration could also be seen as positive potential, forcing the participants to reflect on their roles and perspectives and to further develop their shared understanding of the development project (Engeström, 1999; Hartswood & Procter, 2000).

The purpose of this article is to describe and assess the participatory development process of a palm computer with special software from the work activity system point of view and analyse the benefits and drawbacks experienced by an employee while testing, implementing, and using a new communication and collaboration tool. This study focuses on the maintenance personnel of Company Alpha (the name has been changed for this study). The workers are responsible for the maintenance and serving of real estate.

BACKGROUND

Ergonomics is concerned with human-machine interface technology or user-interface technology, which is often also referred to as microergonomics (Hendrick & Kleiner, 2001). Larger work systems have to be considered when there is a need to better understand human–technology interaction, capabilities, and limitations. Work systems are complex sociotechnical systems (Carayon, 2006), and therefore, it is not relevant to focus on interface design alone when new tools are developed. Macroergonomics is an approach which attempts to achieve a fully harmonised work system at both the macro- and microergonomic levels by integrating principles and perspectives from industrial, work, and organisational psychology (Kleiner, 2006).

Figure 1. The generic work system

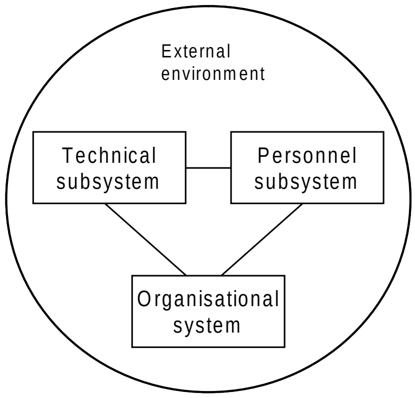

Figure 1 illustrates the generic work system adopted from Kleiner (2006). The work system consists of a personnel subsystem, where two or more people collaborate; a technical subsystem, where people are interacting with technology; and an organisational system, which includes physical and cultural internal environment of an organisation and an external environment.

Mobile work is a potentially interesting area of new applications for mobile ICT. Designing new ICT tools for mobile work systems is a challenge because our understanding of these systems is still fairly limited. Most of the literature addresses the product design from the stationary point of view, either describing the features of a product in a known use context or discussing the product development associated with manufacturing or marketing (Clark & Wheelwright, 1994; Kamrani & Salhieh, 2003; Lewis, 2001; Magrab & Magrah, 1997). Few studies have focused on mobile systems used in highly dynamic contexts (Kjeldskov & Stage, 2004).

Participatory design is a field of research and a progressive practice among professional designers (Kensing & Blomberg, 1998). In participatory design, the end users are invited to cooperate with the developers in a product development process. Potentially, they are expected to participate in several stages of the development process. Among others, Olsson and Jansson (2005) and Kensing and Blomberg (1998) claim that participatory design is essential in developing and testing new products. Ulrich and Eppinger (2004) have also emphasised that an information channel between product users and the designers of the new product has a crucial role in order to discover relevant product features to meet users' needs. However, earlier studies of participatory design have focused on issues like the design process, concept communication, product specification, and prototype trials. Studies rarely focus on the importance of the work contexts where the new products will be used. This article examines the participatory design process from the natural work context view by reporting a case study of a working tool development for the mobile maintenance team.

The people examined represent a group of 12 male employees working under the supervision of one foreman in a maintenance district located in Finland. The data were gathered through semistructured interviews and by observing the working habits of the employees. The model of the generic work system described in Figure 1 was used for analysing the data: the data were coded and classified according to the factors of the system with the help of AtlasTi programme. A parallel coder was used for confirming the reliability of coding. After parallel coding, the parameters of classification were redefined.

MAIN FOCUS OF THE ARTICLE: PARTICIPATION AND COLLABORATION IN WORK AND TOOL DESIGN

Company Alpha maintains and modernises buildings. The real properties to be serviced were divided into districts. The service districts were further divided into maintenance areas, each with one employee responsible for the maintenance. The maintenance work consisted of the service tasks defined in the maintenance contract, emergency situations demanding immediate responses, and possible on-call and specific tasks.

Each employee used a maintenance van to move from one service location to another and transfer all the necessary spare parts and maintenance equipment. The employees drove directly from home to the service area, where they started work at seven o'clock in the morning. They visited the office only for specific reasons. The maintenance men ended their working day at four o'clock after which they drove straight home.

Twelve maintenance men worked as a community and cooperated with each other when necessary, despite working in a mobile and dispersed manner. For communication and collaboration, they used handheld computers and mobile phones.

Employees assisted each other in tasks that could not be completed alone, for instance, for reasons of safety. This added to their job moving outside their own maintenance areas. The maintenance men visited the main office perhaps every two weeks, mostly to pick up equipment for the maintenance van. Usually during these visits, they also met their supervisor. Daily communications with the supervisor were taken care of over the mobile phone.

The company launched a project during the period 2003–2004 aiming at a paperless reporting routine in the tasks of maintenance men. To achieve this, a palm computer with a special program was introduced. The development of software aimed at creating a transferable service entity applicable to the equipment of various manufacturers. The objective of the development work was also to offer employees a simple, easy to use, and portable tool for receiving tasks and reporting on them. The group of maintenance men in this study participated in the experiment.

The employees received their work orders via the palm computer and reported the jobs completed. In the reception of work orders, the maintenance men themselves entered the monthly service lists into the palm computer, and in acute fault situations, the customer service centre sent a message to the maintenance man's palm computer. Reporting on the job took place immediately after working hours and was carried out at the service location. Electronic work reports were the basis of the payroll and acted as the basis for the client invoices.

Benefits and Drawbacks at the Organisational Level

User participation was taken very seriously from the beginning of the development project. All users in the experiment had hands-on training in the test use of the desired system. The main idea was to offer all users the same information and thus underline equality in the development process of the implementation. This goal seems to have been achieved in the light of the interviews. The interviewees thought that they were a part of the development work and considered their own participation very important.

When the worker could see his own contribution to the development, commitment to the new way of working was easy. The interviewees reported that their participation in the development work as significant, since they understood that by participating they were developing tools for their own work and for themselves. The interviewees emphasised that their work experience and knowledge of the tasks were highly appreciated in the development group. They felt free to express ideas on development. From the work activity system point of view, the development covered the whole system, not only the device or the software. The tool and also the real work were developed.

Accelerated customer service was one of the main values and objectives of development. Although the objective for mobile device development was to achieve a portable reporting method, the main value was in customer service. On the go reporting from the job location improved customer service and invoicing. The reports of maintenance measures could be forwarded to clients more quickly than before. Both employer and employee underlined customer service as their main object of their work and thus greatly appreciated this improvement. According to both employer and employees, the device encompassed countless other options for developing the work and its processes. Both groups were well disposed towards further development steps. The employees interviewed emphasized the process of continuous joint development.

Benefits and Drawbacks of the Personnel Subsystem

The collaboration between the employees in the service district was mostly built on indirect interaction. The new software was developed to facilitate this. Contacts between the team members and the supervisor were maintained by phone and text messages. The palm computer was developed for these tasks so that the employee did not need to carry several tools with him. The phone had been implemented relatively recently in the experiment and a few of the employees were using it.

The need to visit the office had decreased and operations were increasingly focused on the service field. Earlier, the repair task codes were read with an IR reader and the information was downloaded once a week at the office. The employees also submitted their time sheets, which were the basis for the payroll. The new practice had decreased the number of office visits and the office was visited once every two weeks to load the van and once every two months for a team meeting. Otherwise, the hours were spent on the service field. Both employer and employees were content with this working mode.

In the earlier practices, the assignments and urgent work tasks were sent to the XTech device in the van, and in crisis situations, the customer service centre also had to phone the maintenance man on duty. In the new working mode, any sudden assignments could be sent to the work location and the maintenance men did not need to return to the van to read the assignment. The new practice had made the ways of contacting employees clearer.

According to the interviews, the palm computer could also be used in the follow-up and control of working hours, since the time of the first opened job was recorded into it and the logout was registered in the machine every day. It would also have been possible to monitor the routes taken and the working locations of employees. The employees thought that they were trusted and therefore the monitoring of the starting time, bookings out, or routes had not been implemented. Trust was very important to them. On the other hand, maintenance men perceived the global positioning system (GPS) monitoring as a safety factor and an opportunity. If something happened, the man on the move could be found easily.

Maintenance work also includes safety risks. Therefore, if the maintenance had not used the software application for one hour, the application would send an inquiry about the situation. If the inquiry was not answered, the application sent a report to the person on-call in the client service centre. For this reason, the inquisitive palm computer had been given nicknames such as Tamaqotchi and Tamara.

Benefits and Drawbacks with the Technical Subsystem

The problems of the new working mode were mostly concerned with the software operations. Uncertainty in the smooth running of the technology had caused some problems in the implementation. The programme operations were not reliable and the programme might, for instance, lose report information. The employee did not receive confirmation upon receipt of the information he had reported. Often, the loss of report information was only discovered when the foreman asked for time sheets. The employees kept a manual double ledger on their work performance in order to remember the details so that payroll and client invoicing could be taken care of.

The phone feature had only been tested for a short period, but the phone development had not been the main issue. Because of the problems in the working mode of the phone, some of the tester employees had given up the use of the phone. Answering incoming calls shut off the other operations and the caller could hear this as a delay when the call was answered. Some interviewees were bothered by this delay.

The most serious obstacle to work was losing unfinished reports when answering an incoming call. After ending the call, the work had to be started from the beginning. Employees would be keen to continue to complete the report, which they consider a routine, even during a phone call. If there were many incoming calls, being able to continue writing the report during them would have been a time-saver. The employees hope they could answer the incoming calls while carrying out a maintenance task without having to stop working. However, when using, for instance, the loud speaker feature, the receiver of the phone call was disturbed by a strong echo that prevented the message from coming or going through.

Because the palm computer was kept in a pocket while moving, they were planned to be light and tiny. However, the problems of visibility emerged when the device was small. For example, the maintenance men had visual difficulties when they moved in dark stairwells and engine rooms. Also, using text message services (SMS) required reasonably good eyesight.

FUTURE TRENDS

Technical problems will be the main challenges for the future in the development project. The employees were, however, satisfied with their new tool and the development process. The main reason for this was their involvement in the development work. Because they felt their thumb prints in both the device and in the development of personal and organisational ways of working, they disregarded many problems of the software developed. This does not mean that they had not noticed the failures of the programme, but instead had a positive attitude towards the new device, the program, and the developing mode of working. This was because the development group paid attention to the work system of the maintenance men.

According to the above findings, a participative approach is essential in the design of the work system. There are three criteria for effective work system design: (i) shared design purpose of the personnel subsystem and the technical subsystem, which should be developed simultaneously and supported by employee participation throughout the entire design process; (ii) the humanised task approach concerned with human functions and tasks in the work system, prior to the decision of allocating tasks to workers or devices; (iii) the consideration of the organisation's sociotechnical characteristics, which should be evaluated and integrated into the design process of the work system. When the selected development methodology fulfills the three above mentioned criteria, the design is human-centred and macroergonomic (Hendrick & Kleiner, 2001).

Figure 2 shows the trend towards the overall work system development. The horizontal axis represents the degree of consideration of the work system when a tool is under development. The vertical axis represents the participation of workers in tool development. The work system development should be an integral part of the tool development and vice versa. This is the way to discover relevant product features and solutions for the real needs of users. There is an emerging need to carry the design characteristics of the overall work system to the design of tools and human interfaces.

CONCLUSION

Although the new device contained many technical problems, the new working concept had many benefits. The new practice, for example, decreased the number of office visits by the employees. The time for the core operations in the maintenance area increased. Even though there were fewer face-to-face meetings of employees and supervisors, the relationship between employer and employees was trustful and based on the results of work, not on monitoring the detailed time usage of employees.

The participation of the employees in the tool development and the consideration of the whole work system proved crucial in committing the personnel to improvements. In the future, the tool development will shift from technical issues to the development of the work systems, where the technical tool development will be emphasised as a part of this. Participatory work system development will be a method to ensure relevant work related product features and solutions.

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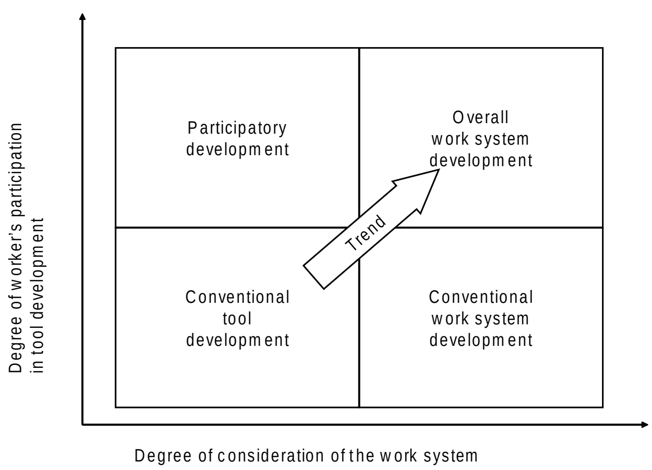
Figure 2. Tool development as a part of work system development



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KEY TERMS

Ergonomics: Ergonomics is the scientific discipline concerned with the understanding of the interactions among humans and the other elements of a work system.

High Intensity Mobile Worker: Works away from the office and away from the main workplace for 10 or more hours in a week.

Human-Centered Approach: Approach to human-machine function and task allocation that first considers the capabilities and limitations of the human and whether the function or task justifies the use of a human.

Macroergonomics: The subdiscipline of ergonomics that focuses on the design and harmonization of the overall work system.

Mobile E-Work: High intensity mobile work in the course of which an online connection to the Internet and to company computer systems is being used.

Mobile Worker: Spends some working time away from home and away from the main workplace such as on business trips, in the field, and customer's premises.

Participatory Design: A design philosophy that uses participative approaches to involve users in the design process.

Pattern-Based Identification in P2P Systems

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INTRODUCTION

This article presents a novel approach to search in shared audio file storages such as P2P based systems. The proposed method is based on the recognition of specific patterns in the audio contents in such a way extending the searching possibility from the description based model to the content based model. The importance of the real-time pattern recognition algorithms that are used on audio data for content-based searching in streaming media is rapidly growing (Liu, Wang, & Chen, 1998). The main problem of such algorithms is the optimal selection of the reference patterns (*soundprints*) used in the recognition procedure. The proposed method is based on distance maximization and is able to quickly choose the pattern that later will be used as reference by the pattern recognition algorithms (Richly, Kozma, Kovács, & Hosszú, 2001). The presented method called *EMESE (experimental media-stream recognizer)* is an important part of a lightweight content-searching method, which is suitable for the investigation of the networkwide shared file storages. The experimental measurement data shown in the article demonstrate the efficiency of the proposed procedure.

BACKGROUND

From the development of *Napster* (Parker, 2004), the Internet based communication has been developed toward the application level networks (ALNs). On the more and more powerful hosts, various collaborative applications run and create virtual (logical) connections with each other (Hosszú, 2005). They establish virtual overlay, and as an alternative of the older client/server model, they use peer-to-peer (P2P) communication. The majority of such systems deal with file sharing; that is why their important task is to search in large, distributed shared file storages (Cohen, 2003; Qiu & Srikant, 2004).

Until now, the search has been usually carried out based on the various attributes of the media contents (Yang & Garcia-Molina, 2002). These metadata are the name of the media file, the name of the authors, data of recording, type of the media content, and maybe some keywords and other descriptive attributes. However, if the incorrect metadata were accidentally recorded, the media file may become invisible due to the misleading descriptions. Currently, the powerful computers give the possibility to implement and widely use pattern recognition methods. Naturally, due to the large amount of media files and their very rich content, very limited pattern identification should be reached as a realistic goal. This article introduces the problem of the media identification based on well-defined pattern recognition.

Another problem is introduced if the pattern-based identification method should be extended form media files to real-time media streams. The hardness of this problem is the requirement that the pattern identification system must work in real-time even in weak computing environments. For this purpose, the full-featured media monitoring methods are not applicable since they require the large processing power in order to run their full-featured pattern recognition algorithms.

The novel system named *EMESE* is dedicated for solving the special problem, where a small but significant pattern should be found in a large voice stream or bulk voice data file in order to identify known sections of audio. Since we limit our review to the sound files, the pattern, which serves for identifying the media content of a file, is named *soundprint*. The developed method is lightweight, meaning that its design goals were the fast operation and relatively small computing power. In order to reach these goals, the length of the pattern to be recognized should be very limited and the total score is not required. This article deals mainly with the heart of the EMESE system, the pattern recognition algorithm, especially with the creation of the reference pattern, the process called *reference selection*.

THE PROBLEM OF PATTERN RECOGNITION

In the field of sound recognition, there are many different methods and applications for specific tasks (Coen, 1995; Kondoz, 1994). The demand for working efficiently with streaming media on the Internet increases rapidly. These audio streams may contain artificial sound effects besides the mix of music and human speech. These effects furthermore may contain signal fragments that are not audible by the ear. As a consequence, processing of this kind of *audio signal* is rather different from the already developed methods, as for example the short-term predictability of the signal is not applicable. The representation of digital audio signal as individual sample values lacks any semantic structure to help automatic identification. For this reason, the audio signal is transformed into several different orthogonal or quasi-orthogonal bases that enable detecting certain properties.

Already, there are solutions for classifying the type of broadcast on radio or television using the audio signal. The solution in Akihito, Hamada, and Tonomura (1998) basically makes a speech/music decision by examining the spectrum for harmonic content and the temporal behavior of the spectral-peek distribution. Although it was applied successfully to that decision problem, it cannot be used for generic recognition purposes. Liu et al. (1998) also describe a scheme classifying a method where the extracted features are based on the short-time spectral distribution represented by a bandwidth and a central frequency value. Several other features, for example, the volume distribution and the pitch contour along the sound clip, are also calculated. The main difficulty of these methods is their high computation-time demand. That is why their application for real-time or fast monitoring is hardly possible when taking the great number of references to be monitored into account.

A similar monitoring problem was introduced in Lourens (1990) and the used feature, a section of the energy envelope of the record signal (*reference*), was correlated with the input (*test*) signal. The demand on real-time execution drove the development of the recognition scheme introduced in Richly, Varga, Hosszú, and Kovács (2000) that is capable of recognizing a pattern of transformed audio signal in an input stream, even in the presence of level-limited noise. This algorithm first selects a short segment of the signal from each record in the set of records to be monitored (Richly et al., 2001).

Carrying out tests on live audio broadcasts showed that the success of identification process depends on the proper selection of the representative short segment. The position where this representative segment can be extracted is determined by the recognition algorithm of the proposed system called EMESE. The selected references must be noncorrelated to avoid false alarms. The method applied in the novel method EMESE is analyzed in the following in order to check how the monitoring system can synchronize to the stream under various conditions, and the measured results are also presented.

THE SOUND IDENTIFICATION IN THE EMESE

The reference selection algorithm needs a well understanding of the recognition method. The audio signal, sampled at f_s*=16kHz*, is transformed into a spectral description. It is a block of data, where the columns are feature vectors of the sound corresponding to a *frame* of time-domain data (N_f*=256* samples, T_f*=16ms* long). First, the amplitude of the Fourier spectrum is computed from the frame. Then, averaging is adapted to the neighboring frequency lines to project the spectrum onto the Bark-scale. The reason for this is to speed up the later comparison stage and to include a well established emphasizing tool used in audio processing, the perceptual modeling of the human auditory system. As a result, we get N_B*=20* values, building up a vector, that are normalized and quantized. Two levels are determined in each transformed frame. The levels are the 10% and 70% of the peak value of the amplitude spectrum. We name the transformed frame a *slice*. In every reference, there are N_S=50 slices of non-overlapping consecutive frames and the audio section, from which the reference was made, is called the *soundprint* of that specific record.

The scheme of the recognition algorithm is to grow the already identified parts of the reference patterns continuously, according to the input. This means that the algorithm takes a frame from the input signal, executes the previously described transformation series, and compares the resulting slice to the actual one of every reference. The actual slice is the first one in every reference by default, and if it is decided to be similar to the slice computed from the input stream (a slice-hit occurs), the next non-overlapping input slice will be compared to the next slice of that reference. If an input slice is decided to be nonsimilar, the actual slice of that reference is reset to the first one. The similarity is evaluated by calculating the weighted Manhattan-distance of the two slices that is the sum of the absolute element-vise differences in the slice vectors.

For achieving more accurate alignment between the test and reference signals, the initial slice-hit in a reference is evaluated using a distance buffer. In this circular-memory, the distances of that first reference slice to overlapping test slices are stored, and the middle of the buffer is examined whether it contains the lowest value in the buffer. In case it does, and it also satisfies the threshold criteria, the identification of the reference proceeds to the next reference slice. This method intends to align the identification process to the "distance-pit" described in the next section. After successfully identifying the last slice of a reference, we successfully identified that record in the monitored input.

THE METHOD OF SELECTING THE REFERENCE PATTERNS

The selection algorithm also uses the previously described weighted Manhattan-distance for measuring the similarity of the audio segments. In the vicinity of the reference's beginning, there have to be frames that vary a lot in the sense of the applied distance metric. This has to be fulfilled because the pattern recognition algorithm cannot synchronize to the given reference otherwise, since the record may appear anywhere in the monitored signal. This way, a robust synchronization can be realized that is also successful in the presence of noise.

If we take a long soundprint (reference candidate) from a record to be monitored and calculate the distance of this section all along the record, then it can be observed that the distance function has a local minimum, a *pit* around the candidate's position. This is demonstrated in Figure 1, where the x-axis shows which frame of the record is compared with the selected candidate, while the y-axis shows the Manhattan-distance values.

To achieve robust synchronization during the recognition, we must guarantee large Manhattan-distance between the candidate and its vicinity. This is assured if the slope of the pit, as shown in Figure 1, is as big as possible. For selecting the best distance-pit and its corresponding candidate section, we should determine the steepness of the pit-side. However, because it is generally not constant, so as an alternative we calculate the width at a given value. Figure 2 shows pit-width of 100 candidate sections, where the sections are extracted from the same record so that their first samples are consecutive in the record. In Figure 2, the horizontal axis is the sample position of the candidate in the record, while the vertical axis is the width of the pits at a record-adaptive level.

Our reference selection algorithm is based on the same principle, but since our pattern recognition method uses the first frame as kernel and grows from the first record, we observed this pit-width for one frame long candidates. The minimum value has to be found in the above function without calculating every point of it. We must also assure that our selected reference does not occur anymore in the record again or in any other records. Using database terminology, we would say that the reference must be a key. To avoid unambiguous identification, we must try to identify the selected reference in all the other records, and if it is not a unique

Figure 1. The "distance-pit" around the reference position

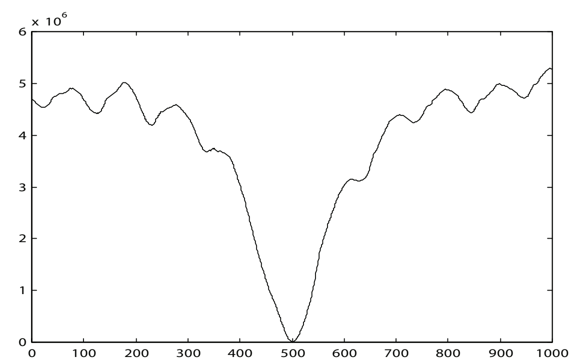
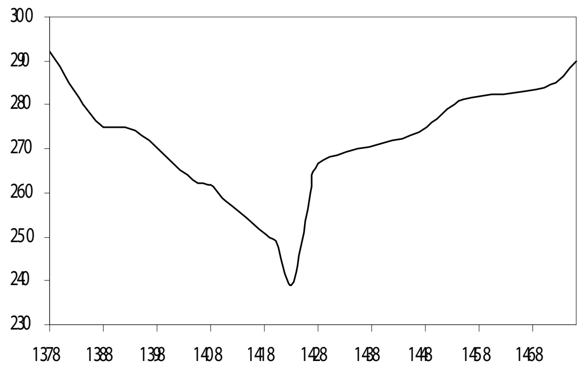


Figure 2. The width of the pits around the sound-print candidate



key, then a new reference must be selected. The exact solution would require us to compare every one of the reference-candidates to every other one. This would mean a lot of comparisons even in the case of a few records that could not be done in a conceivable time period. In the presented algorithm, we tried to keep the number of comparisons as low as possible. To do so, we examine only the vicinity of the reference candidate in a region having the width *w*, where *w* is expressed in number of samples. Also, we do not examine all possible reference candidates, only every one hundredth. The algorithm is listed in Table 1.

RESULTS

Using this algorithm, we selected references from 69 advertisements that previously were recorded from a live Internet audio stream. During the tests, we monitored these 69 advertisements that were broadcast in test Internet stream-media. We added white noise to the input signal to test the robustness of the system. The duration of the test was 48 hours. The recognition results are shown in Figure 3.

We also observed the performance of the system, namely how many references can be handled in real-time. The computer used was equipped with a Pentium-II-350 MHz processor and 256 MB of RAM, and the maximum possible number of references was 258. If the record set to be monitored is added, the reference selection for the added record must be performed, and the new references have to be checked for false alarms. If we detect a possible false alarm due to representative signal similarity, the selection must be repeated for the whole set. This takes 525 minutes in case of 69 records. This is a worst-case scenario, and it should be very rare. The average selection time for every new record is 10 minutes.

The second test was a synchronization test. We selected 50 frames from the stream, and we observed the dependency of the width of the pit on the level of the noise, and the noise level where the monitoring algorithm cannot synchronize to the frame. The result of this test is shown in Figure 4.

FUTURE TRENDS

Based on the continuous development of the host computers, the P2P-based file search systems will have increasing need for the content-based media identification, and also the enhancements in the hardware will provide a possibility to run lightweight but sophisticated and sensitive pattern-based identification methods. Using Internet-oriented pattern identification tools as the EMESE, the content-based search methods will be inherent parts of the e-collaboration and the searching systems.

CONCLUSION

In this article, a reference selection method has been described and realized for an existing real-time recognition algorithm that was used on live audio streams to identify specific sound signals. The proposed selection algorithm takes the properties of the recognition algorithm into account. This algorithm was tested on Internet media streams with a prerecorded signal set, and we reached good results. Further tests should be carried out to determine the exact effect of the input noise level on the width of the distance-pit. The experimental results presented in the article and the described algorithms proved that the pattern-fitting based media identification methods can implement even in Internet-related environment, where the computing power and the quality of the media data are limited.

Table 1. The reference selection algorithm of the EMESE

1. In the first turn, the reference candidate is selected from the $\frac{w}{2}$ th sample of the first region of the given record (The *region* is w=5000 samples). The first region begins on the first sample of the record, and it will define the first sample of the frame.
2. The frame is compared to all possible frames in the region using the distance metric mentioned above. As a result we get $d(i)$, where $i=0\ldots w-N$, as shown on Figure 1.
3. The next region is selected $k*N$ samples forward in the record, and step 2 is repeated. We select further regions the same way and calculate the corresponding $d(i)$ until we reach the end of the record.
4. The steepest pit and the corresponding i_{opt} frame position in the record is selected examining all the $d(i)$ functions for the narrowest pit.
5. In the $k*N$ vicinity of position i_{opt} the frame with the narrowest distance-pit is determined using a gradient search algorithm. This is the lowest point of the function on *Figure 2*.
6. The reference consisting of N_R slices (transformed frames) is extracted from the record beginning with the frame selected in the previous step.
7. This reference is tested for uniqueness using the recognition algorithm. If the reference appears in the record more than once, not only at the correct position, then the next best reference must be selected in the previously described way.
8. The reference is then tried against all the other records, to filter out in-set false alarms. If the reference is found in any other record, step 7 is used for reference reselection.
9. The above steps are applied to all other records.

Figure 3. Percentage of patterns successfully identified by the recognition algorithm

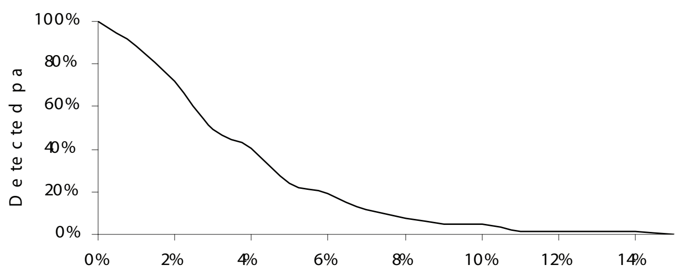
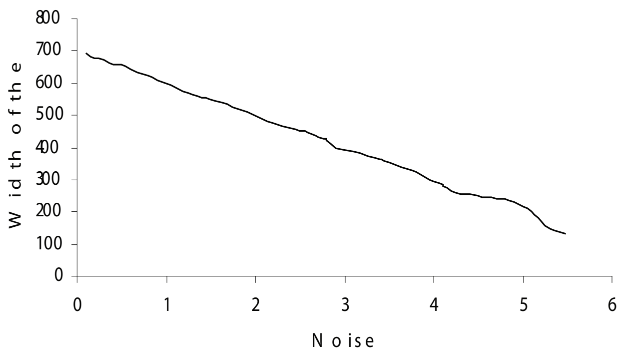


Figure 4. Result of the synchronization test



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KEY TERMS

Application Level Network (ALN): The applications, which are running in the hosts, can create a virtual network from their logical connections. This virtual network is also called ***overlay***. The operations of such software entities are not able to understand without knowing their logical relations. In most cases, these ALN software entities use the ***P2P model***, not the ***client/server*** model for the communication.

Audio Signal Processing: It means the coding, decoding, playing, and content handling of the audio data files and streams.

Bark-Scale: A nonlinear frequency scale modeling the resolution of the human hearing system. 1 Bark distance on the Bark-scale equals to the so called critical bandwidth that is linearly proportional to the frequency under 500Hz and logarithmically above that. The critical bandwidth can be measured by the simultaneous frequency masking effect of the ear.

Client/Server Model: A communicating way where one host has more functionality than the other. It differs from the P2P model.

Content-Based Recognition: The media data are identified based on their content and not based on the attributes of their files. Its other name is content-sensitive searching.

Manhattan-Distance: The L_1 metric for the points of the Euclidean space defined by summing the absolute coordinate differences of two points (|x2-x1|+|y2-y1|+…). Also known as "city block" or "taxi-cab" distance; a car drives this far in a lattice-like street pattern.

Overlay: The applications, which create an ALN, work together, and they usually follow the P2P communication model.

Pattern Recognition: It means the procedure of finding a certain series of signals in a longer data file or signal stream.

Peer-to-Peer (P2P) Model: A communication way where each node has the same authority and communication capability. They create a virtual network, overlaid on the Internet. Its members organize themselves into a topology for data transmission.

Synchronization: It is the name of that procedure, which is carried out for finding the appropriate points in two or more streams for the correct parallel, playing out.

Product Evaluation Services for E-Commerce

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INTRODUCTION

Despite the rapid growth of e-commerce and the hype surrounding it, the potential of the Internet for truly transforming commerce is largely unrealized to date is because most electronic purchases are still largely non-automated. User presence is still required in all stages of the buying process. According to the nomenclature of Maes' group in the MIT Media Labs (Guttman, 1999; Maes, 1994), the common commerce behavior can be described with consumer buying behavior (CBB) model, which consists of six stages, namely, need identification, product brokering, merchant brokering, negotiation, purchase and delivery, and product service and evaluation.

The solution to automating electronic purchases could lie in the employment of software agents and relevant AI technologies in e-commerce. Software agent technologies can be used to automate several of the most time consuming stages of the buying process like product information gathering and comparison. Unlike "traditional" software, software agents are personalized (Guan, Zhu, & Maung, 2004; Wang, Guan, & Chan, 2002; Zhu, Guan, & Yang, 2000), continuously running, mobile (Guan & Yang, 1999; Guan & Yang, 2002; Ouardani, Pierre, Boucheneb, in press) and semi-autonomous. These qualities are conducive for optimizing the whole buying experience and revolutionizing commerce, as we know it today. Software agents could monitor quantity and usage patterns, collect information on vendors and products that may fit the needs of the owner, evaluate different offerings, make decisions on which merchants and products to pursue, negotiate the terms of transactions with these merchants and finally place orders and make automated payments (Guan & Hua, 2003; Hua & Guan, 2000; Poh & Guan, 2000) if they are secure (Esparza, Muñoz, Soriano, Forné, 2006; Guan & Yang, 2004).

At present, there are some software agents like BargainFinder, Jango and Firefly providing ranked lists based on the prices of merchant products. However, these shopping agents fail to resolve the challenges presented next:

Seller Differentiation

Many merchants deny entry of such comparison agents into their site and refuse to be rated by these agents for this reason. Unless product comparisons can be performed in a multidimensional way, merchants will continue to show strong resistance towards admitting software agents with product comparison functions into their sites.

Buyer Differentiation

Although comparison between products based on price and features is currently available on the Internet, this feature is only useful to the buyer with relevant product knowledge. What is truly needed is a means of selecting products that match the users' purchase requirements and preferences. These preferential purchase values include affordability, portability, brand loyalty, and other high level values that a user would usually consider in the normal purchase process.

Differentiation Change

In today's world of rapid technological innovation, product features that are desirable yesterday may not be desirable today. Therefore, product recommendation models must be adaptable to the dynamic, changing nature of feature desirability.

The current agents also do not have complete interpretation capability of the products because vendor information is described in unstructured HTML files in a natural language. Finally, there is also the issue that the agents may need a long time in order to locate the relevant product information given the vast amounts of information available online. A more coordinated structure is required to ensure faster search time and more meaningful basis for product comparison. It is, therefore, the aim of this chapter to propose a methodology for agent learning that determines the desirability of a product and to propose an agent framework for meaningful product definition to enable value-based product evaluation and selection.

LITERATURE REVIEW

In this section, we consider some of the online solutions that are currently applied on the Internet for product comparison and recommendation and a number of agent architectures proposed for electronic commerce.

Internet Models

The most common Internet model for e-commerce product selection is feature-based product comparison. Most search engines are able to collate the relevant product information for a specified number of the filtered products and present the outcome in the form of a comparison table. The drawback from this scheme is that it is usually only able to make comparisons between a specified number of products. There is also no strong basis for making product recommendations based only on the product features without consideration for the user's preferences.

Several dot.com startups like allExperts.com and epinions.com use a network of Web users who contribute their opinions about a specific product to assist a user to make product purchase decisions. The drawback from this scheme is that the process of product filtering, which is the precursor to product evaluation, is usually absent. Furthermore, the opinions of the contributors could be based on different value judgements. Thus, what may be desirable to a user need not be so for another user.

Agent Frameworks

Little research has been done in this area; however, there are a number of operations research techniques available to consider for this purpose like in Lee and Lee (1998). The main problem with these agent frameworks is that the product domains are distinct and separate. However, for a complex system like a personal computer system where component level information is widely available, it would be a definite advantage to be able to mobilize the relevant product agents together to give a better evaluation of the given product. There is therefore insufficient agent integration towards product recommendation. The cause of this problem most probably lies in the form of knowledge representation for the products.

ARCHITECTURE OF AGENT-BASED TRADE SERVICES

SAFER - *S*ecure *A*gent *F*abrication, *E*volution and *R*oaming for electronic commerce (Guan & Yang, 1999) is an infrastructure to serve agents in e-commerce and establish the necessary mechanisms to manipulate them. SAFER has been proposed as an infrastructure for intelligent mobile agent mediated e-commerce. The proposed Trade Services is best positioned based on such an infrastructure, which offers services such as agent administration, agent migration, agent fabrication, e-banking, and so forth.

The central design questions raised are:

How does a purchase agent locate relevant vendor agents among the sea of agents in the World Wide Web?

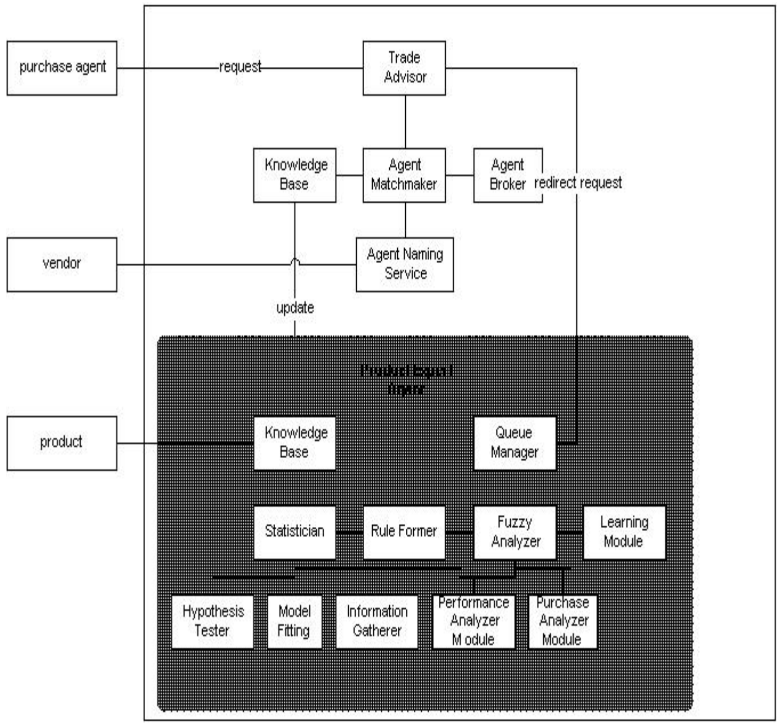
After the products have been found, how does the agent evaluate the performance and desirability of a particular product and make good recommendations?

Our solution would be an Agent-based Trade Services entity.

Trade Services

A trusted trade services entity is proposed for each agent community (Zhu et al., 2000). All the vendors participating in the framework are to be registered with the Trade Services and the products to be sold within the agent framework are also to be registered. In thus doing, the approach also overcomes the potential problem of an overtly long product searching process when there is no known directory for the purchase agents to locate a product and related vendor information quickly. The Trade Services, in this role, acts as an intermediary between the purchase agents and the vendor agents and provides the facilities for agent matchmaking and agent brokering. The Agent Naming Service provides the mapping of agent names and their locations while the Agent Broker maintains the mapping of agents and their capabilities within the framework.

Figure 1. Agent-based trade services



The trade services is proposed to be a neutral, logical entity that embodies a collection of autonomous expert agents, each capable of handling a specific domain. However, the trade services needs not play a merely passive role as a routing mechanism in a client-server framework that connects the purchase agent to the relevant expert agent. It also plays an active role in providing interconnectivity between the various expert agents in order to achieve a better evaluation of the product. This "divide-and-conquer" approach will be especially useful in evaluating complex, composite products like the PC, where reliable evaluation of individual components could be the key to a reliable overall recommendation. This could mean that the Trade Services needs to have some meta-knowledge about the relationships between products and these relationships could be built into the knowledge base by the manner the product information was represented.

The advantages to a multiagent trade services approach are:

- **Lower search cost and waiting time:** If each expert agent handles its own knowledge base, the extent for a search is greatly limited, leading to a faster search time. The queue for services from the trade services could be split into shorter queues for individual expert agents, thus reducing the mean waiting time for requests. This again will lead to superior performance from the system.
- **Knowledge representation of the domain can be uniquely determined:** Ambiguity that may arise from similar terminology employed for different products is avoided. Specific ontology for agent communication on product specification level can also be established along product lines.

Some Components of the Agent-Based Trade Services

Expert agent plays an active role in providing interconnectivity between the various expert agents in order to achieve a better evaluation of the product. It conducts its own learning based on the statistics and inferences derived from the acquired knowledge. Thus, it should have knowledge base, a statistics-gathering module, one or more learning mechanisms, and a reasoning engine that is capable of handling uncertainty in the knowledge.

Queue Manager Managed Simultaneous Requests for the Services of the Same Expert Agent

The Statistician entity acting in the Information Gatherer role extracts salient information about the product category like the maximum, minimum, and the mean values of the product features. Rule-Former analyses the product category and forms rules out of it.

The performance analyzer module is a fuzzy-logic module that determines the performance of the product based on the feature values of the product that affect its operational performance. The purchase analyzer module is another fuzzy-logic module whose purpose is to make recommendations of the products that meet the feature specifications dictated by the user.

Product Evaluation Methodology

Whilst the price of a product may not be an absolutely accurate indication of the desirability or the performance of the product, it is nevertheless a very good indicator in most cases. Therefore, in order to ascertain the desirability of a certain product feature, the relationship between the feature value and the price of the product may be used as a heuristic. After the salient features of a product are determined, statistical tests may be conducted to ascertain the correlation that exists between the feature value and the price of a product. A possible method of determining if a feature is useful in the purchase decision is to consider the frequency of occurrence of that feature in all the registered products in the specified category. An alternative way of approach is to use the concepts of information theory in the same way it is being applied to decision trees, that is, to determine those factors that contribute the most information about the product.

Spearman's rank correlation test (Devore, 2000) is then performed on the ranked list of products in the category to determine whether any correlation exists between the price of a product and the attribute value for each of its features. The correlation forms useful heuristics to allow the Rule-Former to determine the rules that evaluate product performance and desirability.

After the general correlation is obtained, the feature-price model can be fitted with either a linear or nonlinear regression model. Linear correlation can be easily obtained from Pearson correlation coefficients and linear regression model techniques. For the nonlinear correlation model, it is observed that most of the price-attribute correlations exist in a monotonic manner. Therefore, we only need to consider intrinsically linear functions to model the relationship. This greatly simplifies the mathematical modeling complexity as the choice of the model can be reduced to merely three main categories—the logarithmic model, the exponential model and the power model, and for which the parameters can be easily obtained.

It is further argued that the correlation model obtained is an indication of the desirability of the product feature. That is, we can assume that the price-attribute correlation to be equivalent to the desirability-attribute correlation for a product feature. This correlation can then be assigned as the membership function of a fuzzy logic variable upon which fuzzy inferences and reasoning can be performed to evaluate the product.

Agent Learning

Where there are established benchmarks for evaluating product performances, these data could be used to train the agent and tune the membership functions for the fuzzy components. Tuning of fuzzy membership functions are usually done with genetic algorithms.

RESULTS AND DISCUSSIONS

A prototype was developed to provide for a test of concept. The prototype handles the purchase of a CPU processor. The performance of each processor was evaluated with a fuzzy-logic reasoning engine employing Mamdani implication and center-of-gravity defuzzification. The results obtained are shown next.

The performance rating for the processors as determined by the performance analyzer module is compared against the official processor benchmark values as given by the manufacturers. This benchmark is based on the ICOMP 3.0 (http://cpuscorecard.com) benchmark adopted by Intel.

The ICOMP 3.0 scores were normalized against the maximum value obtained to establish a basis for comparison with the results from the Performance Analyzer. When the raw scores from the Performance Analyzer were compared against that of the normalized ICMP 3.0 scores, the results did not

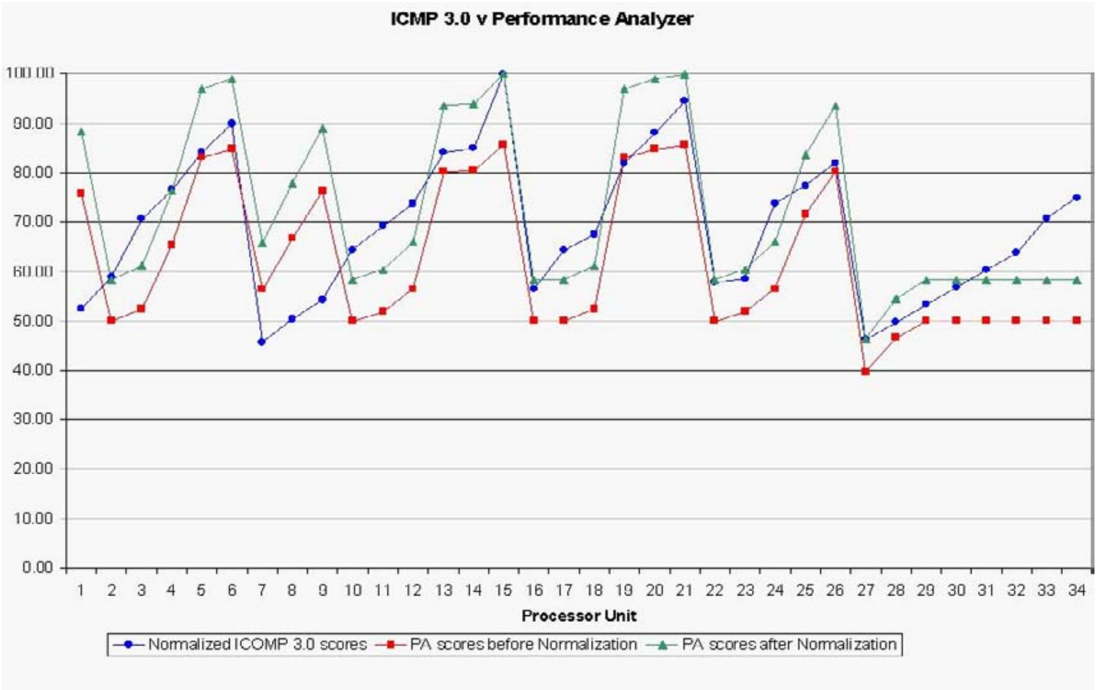
Table 1. Performance comparison of CPUs

Processsor Speed	Cache size	Bus-speed	ICMP 3.0 Performance		Performance Analyzer Performance	
			Raw Score	Percentage	Raw Score	Normalized
533	512	133	1721	52.47	75.8	88.45
600	256	133	1930	58.84	50.0	58.34
667	256	133	2320	70.73	52.4	61.14
733	256	133	2510	76.52	65.4	76.31
800	256	133	2760	84.15	83.1	96.97
866	256	133	2949	89.91	84.8	98.95
450	512	100	1500	45.73	56.4	65.81
500	512	100	1650	50.30	66.8	77.95
550	512	100	1780	54.27	76.3	89.03
600	256	100	2110	64.33	50.0	58.34
650	256	100	2270	69.21	51.8	60.44
700	256	100	2420	73.78	56.5	65.93
800	256	100	2760	84.15	80.2	93.58
850	256	100	2790	85.06	80.4	93.82
1000	256	133	3280	100.00	85.7	100.00
533	256	133	1850	56.40	50.0	58.34
600	256	133	2108	64.27	50.0	58.34
667	256	133	2214	67.50	52.4	61.14
800	256	133	2690	82.01	83.1	96.97
866	256	133	2890	88.11	84.8	98.95
933	256	133	3100	94.51	85.6	99.88
550	256	100	1900	57.93	50.0	58.34
650	256	100	1922	58.60	51.8	60.44
700	256	100	2420	73.78	56.5	65.93
750	256	100	2540	77.44	71.7	83.66
800	256	100	2690	82.01	80.2	93.58
533	128	66	1517	46.25	39.7	46.32
566	128	66	1631	49.73	46.7	54.49
600	128	66	1749	53.32	50.0	58.34
633	128	66	1863	56.80	50.0	58.34
667	128	66	1980	60.37	50.0	58.34
700	128	66	2094	63.84	50.0	58.34
766	128	66	2322	70.79	50.0	58.34
800	128	66	2459	74.97	50.0	58.34

appear to be too encouraging, as the difference in values seems to be rather wide. The maximum value provided by the performance analyzer is only 85.7. This is a drawback of using the product-moment defuzzification scheme for fuzzy logic systems. A possible way around this problem is to normalize the results and after doing so, the results from the Performance Analyzer were quite similar to that of ICOMP 3.0. To ascertain if positive correlation exists between the two sets of ratings, the Spearman's rank correlation coefficient was calculated. It was found to have a value of 0.703. This is much greater than the critical value of 0.432 required at 1-% significance level. Therefore, we claim that the results from the Performance Analyzer show positive correlation with the ICOMP 3.0 results.

However, it was observed that the fuzzy module showed low level of sensitivity when the cache-size and bus speed are low. An analysis of the surface plot for the bus-cache relationship when

Figure 2. Performance analyzer results



the processor speed was set to 600 MHz revealed a relatively flat surface over a wide range of values, thus accounting for the insensitivity.

FUTURE TRENDS

For future work, the performance of the fuzzy logic modules could be improved by fine-tuning using genetic algorithms. The most important features of a product can be determined using decision trees and extracting those attributes that contribute the most information. Case-based learning algorithms can also be implemented into agents to handle situations where all the user's criteria cannot be met simultaneously.

CONCLUSION

In conclusion, it was shown through the prototype implementation that intelligent agent is a feasible approach to handle the uncertainty involved in product selection and evaluation. This could be a step towards embedding more intelligence in e-commerce. The knowledge base implementation of Trade Services for product services caters to the possibility of further reasoning using AI techniques like forward chaining and backward chaining. The proposed architecture for Trade Services as a logical entity comprising of a group of intelligent agents allows greater integration of the expert agents towards product evaluation where component-wise evaluation of a complex product is possible.

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KEY TERMS

Agents: A piece of software, which acts to accomplish tasks on behalf of its user.

E-Commerce: The conducting of business transactions over networks and through computers.

Client-Server: A network architecture consisting of *clienst* or *server*s. Servers are computers or processes dedicated to managing files, databases or network resources. Clients are computers on which users run applications.

Genetic Algorithm: An evolutionary algorithm which generates each individual from some encoded form known as “chromosomes” or “genome”.

Heuristic: A set of rules intended to increase probability of solving problem.

Fuzzy Logic: An extension of Boolean logic that deals with the concept of partial. It is useful in clustering, expert systems and other intelligent system applications.

SAFER: An infrastructure to serve agents in e-commerce and establish the necessary mechanisms to manipulate them. The goal of SAFER is to construct standard, dynamic and evolutionary agent systems for e-commerce (Guan, 1999).

Quality Assurance View of a Management Information System

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INTRODUCTION

Strategic management has been widely applied in public and private organizations. Strategic management adapts educational institutions to their environment, which includes the educational policy, local demand for labour and other circumstances. The increased autonomy of educational institutions has emphasised the role of strategic management. Quality assurance has also gained more attention in recent years when plans have been made to establish the European Higher Education Area (Berlin Communiqué, 2003).

European countries develop their own national solutions for evaluating and demonstrating the quality of degrees (FINHEEC, 2006). There are no European or national agreements that provide any specific approaches or tools for the management of higher education institutions (HEIs) (Maassen & Stensaker, 2003). Each HEI is responsible for defining its management and quality assurance systems. Strategic management is a strong candidate for the management system for Finnish HEIs, but there is more variation in the quality assurance systems. Quality assurance refers to quality management and improvement. Quality is understood as the ability of an institution to fulfill its mission or a study programme to fulfill its aims (Harvey, 2007; Harvey & Green, 1993).

The purpose of this chapter is to describe the management information system (MIS) which integrates strategic management and quality assurance. Institutional quality audits have shown that quality assurance is quite often separate from the general management system of HEIs. By contrast, a well-functioning quality assurance system produces evaluative information about results and processes and then management uses this information to develop processes. Management at each institutional level determines the corrective action. While providing support for strategic management, the management information system can also contribute to continuous improvement, which is the core of quality assurance.

The balanced scorecard approach developed by Kaplan and Norton (1996, 2001) translates the strategy into action and provides a framework to integrate the strategic management and quality assurance approaches. This chapter describes the case of the Turku University of Applied Sciences (TUAS). At the TUAS, the implementation of the strategic plan includes, among others, budgeting, action plans and HR plans, which are stored in the MIS portal. The balanced scorecard is used to create an understandable structure for the strategic and action plans which include quantitative measures. All these management and quality assurance tools are provided for the managers and personnel as the tools of the MIS portal.

BACKGROUND

Quality Assurance in Higher Education

The Bologna Process Finland has developed its own approach to quality assurance in higher education. The approach is based on the quality assurance systems of HEIs and external quality audits at the institutional level. The quality assurance systems of all Finnish HEIs will be evaluated by the Finnish Higher Education Evaluation Council (FINHEEC) by 2011. Each institution is responsible for the development of its own quality assurance system. HEIs have the responsibility to define what they mean by quality and how they manage and enhance quality. The external audits aim to evaluate how the quality assurance system of an institution performs as a tool for quality management and enhancement. The institutional quality audit ascertains whether a quality assurance system produces useful information for continuous improvement (FINHEEC, 2006).

When building a quality assurance system, the first step is to define the concept of quality. In everyday language, the word "quality" has been associated with excellence. However, fitness for purpose is the approach to quality accepted by most quality agencies. Fitness for purpose sees quality as fulfilling a customer's requirements, needs, or desires. In higher education, fitness for purpose is understood as the ability of an institution to fulfill its mission or a study program to fulfill its aims (Harvey, 2007; Harvey & Green, 1993). This is the definition adopted in this chapter. At the institutional and faculty level, quality is defined in the institution's mission, strategic plan, and annual action plans and evaluated against these plans.

The concept of quality assurance has various definitions in different contexts. According to Woodhouse (1999) quality assurance refers to the policies, attitudes, actions, and procedures necessary to ensure that quality is maintained and enhanced. Quality assurance is defined in this chapter to include strategic management and the performance of the internal processes. A similar interpretation is given by FINHEEC (2006), which states that quality assurance is part of strategic planning and includes the management process and the internal processes of HEIs. Quality assurance refers to the procedures, processes, and systems which safeguard and improve the quality of an HEI, its education, and other activities. At the level of HEIs, the quality assurance system refers to the entity composed of the quality assurance organization, the respective responsibilities, procedures, processes, and resources.

The relationship between the strategic management and quality assurance of higher education institutions could be interpreted as a new conceptualization for some of the most essential features of quality assurance. From our viewpoint, two basic ideas of quality assurance are continuous improvement and management's commitment. According to Beckford (2002), the principle of continuous improvement is an explicit part of the thinking of many quality gurus. Furthermore, John Oakland says, "Quality must be managed, it does not just happen", and Beckford argues that without adherence to the quality management system, it is impossible for the organization to know how well it is performing.

It is evident that management is an essential element of quality assurance. Mostly it is only the managers who possess the power and resources needed for carrying out the planned development steps (corrective action). One way to look more profoundly at the relationship between strategic management and quality assurance is to emphasise the fitness of purpose and use the phases: plan, do, check, and act (PDCA). This is known as Deming's cycle (Beckford, 2002). The cycle has been used in various quality awards. The Malcom Baldrige quality award has renamed it and uses the words: approach, deployment, results and improvement (ADRI) (Woodhouse, 2003).

Figure 1 presents the quality cycle of continuous improvement. The approach is about planning what will be done and how it will be done. Deployment is about how to implement these plans. The results are the consequences of these actions. At this point, the results may be accepted as such and no changes are made to the approach or deployment. Often results are unsatisfactory and objectives have not been achieved. Then a systematic reflection about what approach and deployment led to these results may suggest useful improvement measures (Woodhouse, 2003).

MAIN FOCUS OF THE ARTICLE

The Quality Map

The concept of the quality map is introduced to describe the quality assurance of an organization. The quality map is a visual representation of the cause-and-effect relationships among the objectives of education policy, regional strategies and the institutional strategic plans. It provides an insight into the management, personnel and stakeholders to understand the main elements of quality assurance. The quality map is a graphical representation of quality assurance. We have developed the concept of a quality map from the strategy maps introduced by Kaplan and Norton (2004). A quality map describes the essential characteristics of the quality assurance system like a road map, but omits all the minor details.

Figure 2 describes the quality map of the TUAS. The quality map shows that quality assurance is a comprehensive concept including the strategic planning, the management process and the internal processes and structures of the organization. There is a continuous flow of communication and interaction between these elements. The description of the quality assurance sys-

Figure 1. Quality cycle of continuous improvement

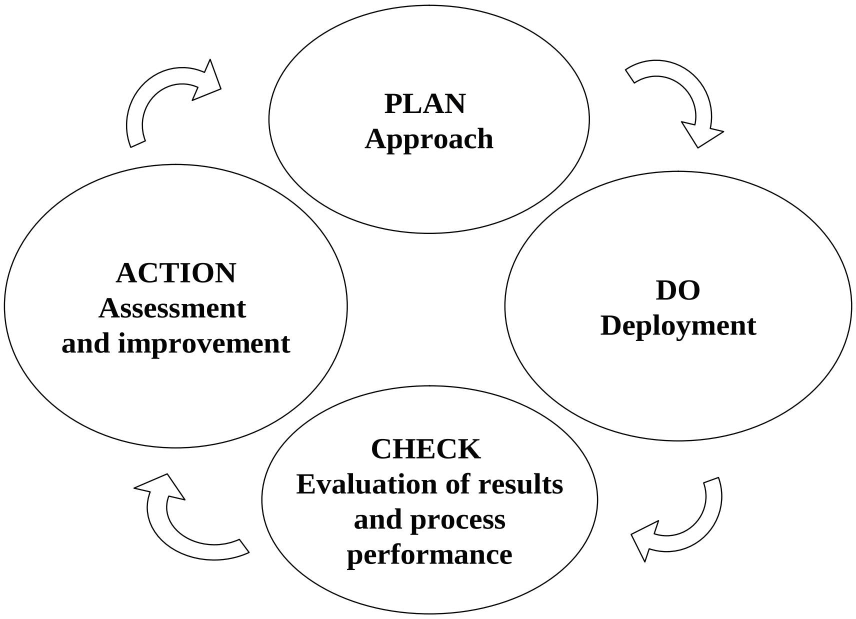
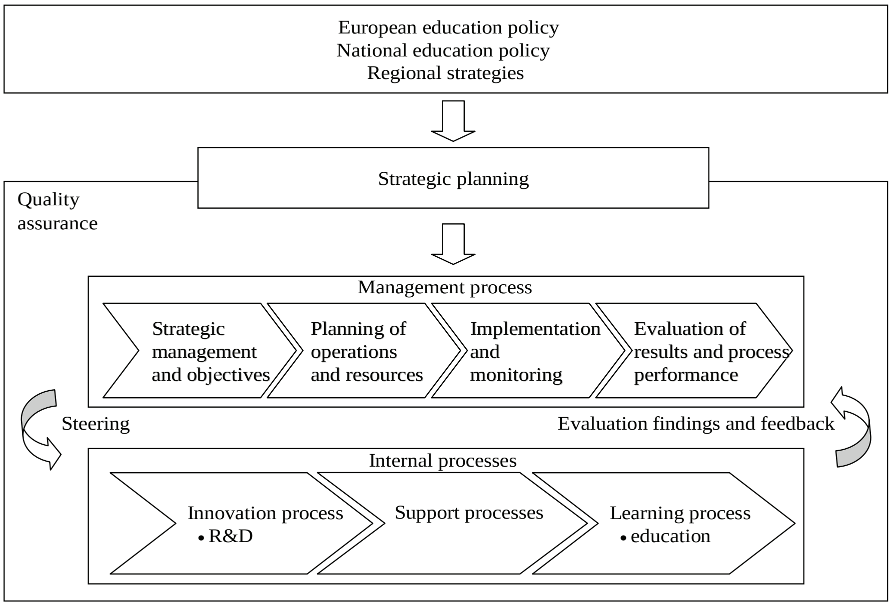


Figure 2. The quality map of the TUAS



tem is an attempt to formalize the diffuse knowledge and context-sensitive procedures.

The management process includes sequential planning and management activities. They include the strategic management and objectives, the planning of operations and resources, implementation and monitoring, and finally, the evaluation of results and process performance. The strategy process produces the strategic objectives for the planning period. The operations of the internal processes are aligned with budgeting and human resources planning. The achievement of results is regularly monitored and ensured to achieve the desired objectives during the planning year. Finally, the achievement of objectives is evaluated and reported to stakeholders.

The main internal processes include the innovation process (research and development), support processes (support services) and education (teaching and learning processes). The strategic planning and quality assurance overlap. The involvement of students, members of the personnel and external stakeholders in strategic planning is an important means of quality assurance.

The linkages between the management process and internal processes describe the guidance and information flows which have to be taken into account in the continuous improvement of activities. The aim of the management process is to steer the development of internal processes. Another linkage is the feedback and evaluation results from different sources, which include students, employers and self-assessments. The action plans located in the MIS are used to collect and store the steering information and development steps which may be based on self-assessment, feedback, or external evaluation.

The Management Information System

Without proper management tools it would be nearly impossible for administrators and evaluators to know how well the institution, department, or program is performing. The introduction of the balanced scorecard approach in 2002 laid the foundation for developing the management information system at the TUAS. Balanced scorecards were planned for all the administrative units of the institution. It was evident from the beginning that without any proper tools the maintenance of the scorecards was troublesome. The consistent aggregation of the scorecards to the upper organizational level needed automation. The data collection from the various data sources also needed automation. It was evident that the new MIS would provide clear benefits as required generally for development projects of this kind (Galliers & Sutherland, 1991; Galliers, Swatman, & Swatman, 1995).

The development and description of the management process started at the beginning of 2004. The entire management process was described in detail. About 700 concepts were defined and the data model was developed. More detailed process descriptions and specifications for the services provided by the portal were written to facilitate the automation of the process. It is important that the management process be entirely developed and described before the planning of the information system. It is also important that there is a well-defined and widely used approach to communicate and implement the strategic plans. The balanced scorecard approach clearly fulfills this requirement (Kettunen, 2004, 2005; Kettunen & Kantola, 2005). The first services of the portal were launched in the autumn of 2005 and the implementation continued through 2006.

The MIS portal was developed to support the management process. The members of the personnel have diverse user rights and roles in the interactive management tool. The administrative units are able to draft their strategic plans, action plans, budgets and human resources plans. The action plan of the units is important, because it describes the implementation of the strategic plan, timetables and responsibilities. The action plan also defines the development steps based on the evaluative information produced by the quality assurance system. The portal has been planned to be accessible to the personnel and to make the strategic planning understandable. The portal takes advantage of the data warehouse.

Data warehousing effectively utilizes the various data sources including personnel administration, financial planning, and student and study registers. The data warehouse captures data from data sources, makes transformations, and directs data to an integrated database (Guan, Nunez, & Welsh, 2002; Inmon, 1996). Sometimes these are called extract, transform and load (ETL) processes. Before the introduction of the data warehouse, the data were scattered and undocumented. Data collection was also unreliable because it was to a large extent collected manually from separate data sources or personal files.

The Management Information System Integrates Strategic Planning and Quality Assurance

The MIS is an electronic platform which effectively integrates the elements of strategic planning and quality assurance. The MIS provides strategic plans which are then implemented using the action plans and the tools for budgeting and human resources planning. This is evident when one compares the stages of the quality cycle (Figure 1) with the tools of the MIS portal. The strategic and action plans represent the approach stage of the cycle. The action plan contains reliable quantitative information about results and process performance. This information strongly supports management in the search for strengths and weaknesses. The MIS portal can be seen as an evaluation tool which supports the evaluation of the results stage of the quality cycle.

The action plan includes not only information about process performance but also about how to improve processes. The development steps on the basis of assessment are decided by the management at each institutional level. At the TUAS, the development steps are stored in the MIS as part of the action plans of the institution, its faculties and programmes. This is an illustration of how the portal supports the assessment and improvement stage of the quality cycle.

The action plan must identify the strategic initiatives and development steps at different organizational levels. The action plan must identify the timetables and individuals responsible for the planned tasks. All in all, the action plan is an electronic document where the implementation of strategic plans and development steps of quality assurance meet.

The effectiveness of strategic planning and quality assurance is crucial in how the strategic initiatives and development steps based on the evaluations and feedback can be integrated into the core institutional processes and functions. It is evident that these two approaches of management are most efficient when they are transformed into action close to teaching and learning. These approaches should be implemented at the different organizational levels of the institutions including the departments, degree programmes, teachers and students. Strategic planning and quality assurance must be implemented in the action plan, curriculum, course implementation plans, teacher workload plans and personal study plans of students.

FUTURE TRENDS

An obvious future trend is that electronic tools will be widely used in supporting the management process. The strategic plan is updated every fourth year at the TUAS, but the implementation of the strategy and detailed planning of activities are annually performed following the management process. The measures describing the strategic objectives are updated annually using the MIS portal and agreed in the internal target discussions. These group negotiations are led by the Rector and have strong steering elements, because the tasks are directly derived from the strategic objectives and written into the action plans. The target values of the measures are updated and agreed in these target discussions.

The second obvious trend is the harmonization of the MISs in the different HEIs. There are plans to collect a database of the process descriptions among Finnish universities. The concepts related to institutional management have also been defined and collected. A vision has been presented in the working group of the Ministry of Education that a national data warehouse should be planned to collect the information on students, degrees and ECTS credits in a common database to facilitate student mobility. There is also a need to integrate the national statistical databases of the universities and universities of applied sciences, which are separate nowadays and have different structures.

CONCLUSION

The concept of the quality map was introduced in this chapter to describe the integration of strategic management and quality assurance. The quality map is a visual description of how education policy and regional strategies are used to define the strategic objectives of the institution. The strategy map also describes the management process and the main internal processes of the institution. The visual representation of quality assurance helps the management, employees and stakeholders of an organization to understand the main elements and linkages of quality assurance.

This chapter shows that the different approaches of management can be integrated using an MIS. An advantage of the electronic management tool is that it supports the management process and the internal activities of the organization. It is a virtual platform for consistent strategic planning in the different organizational units. It is also a platform for quality assurance based on internal and external evaluations. This study also supports the view that the balanced scorecard is a useful tool for the basis of the MIS and the integration of different management approaches and tools.

The open MIS increases strategic awareness among managers and members of the personnel. The integration of management approaches and the alignment of the strategic objectives in the different organizational units help management to create a shared understanding among the personnel about the implementation of the strategic plan and the development steps based on the information produced by the quality assurance system.

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KEY TERMS

Balanced Scorecard: The balanced scorecard approach is a framework for the communication and implementation of the strategy. The balanced scorecard approach translates the strategy of an organization into tangible objectives and measures and balances them typically into four different perspectives: customers, financial outcomes, internal processes, and learning.

Higher Education Institution: Higher education institutions include traditional scientific universities and professional-oriented institutions, which are called universities of applied sciences or polytechnics.

Management Information System: A proper management information system presupposes modelling the entire management process and tailoring all the necessary components of the information technology support system to meet the needs of the organization. The management information system should include a description and measures of how the strategic objectives will be achieved.

Quality Assurance: Assurance of quality in higher education is the process of establishing stakeholder confidence that provision (input, process and outcomes) fulfills expectations or measures up to threshold minimum requirements. Quality assurance refers to the procedures, processes and systems that safeguard and improve the quality of a HEI, its education and other activities.

Quality Enhancement: Enhancement is a process of improvement. In relation to higher education quality, enhancement may refer to: (1) individual learners when it means improvement of the attributes, knowledge, ability, skills, and potential of learners; (2) the improvement in the quality of an institution or study programme.

Quality Management: Quality management emphasises the importance of management's commitment to quality. Quality must be managed; it does not just happen.

Strategic Management: Strategic management is a matter of bridge building between the perceived present situation and the desired future situation. Strategy implies the movement of an organization from its present position, described by the mission, to a desirable but uncertain future position, described by the vision.

The Relationship Between Assessment and Evaluation in CSCL

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INTRODUCTION

In the educational field, evaluation is a very complex activity due to the intrinsically multidimensional nature of the processes to be evaluated. Several variables must be taken into consideration, and they interact and influence one another: the object and the goal of the evaluation determines the criteria, the methods, and the data to be used for the evaluation. In this chapter, we will focus on evaluation in computer-supported collaborative learning (CSCL). In this field, a primary role is played by the *monitoring* process, which allows us to gather important information about the learning process while it takes place. Indeed, monitoring serves three purposes: it provides real-time data about group dynamics so that they can be used by tutors to facilitate learning and stimulate collaboration among trainees; it provides designers and evaluators with data about learning system usage that are needed to evaluate its effectiveness; finally, it supplies information about the learning process and its outcomes, thereby informing assessment. Hence, monitoring can be seen as a sort of common denominator between the methods used to foster collaborative learning and those that allow the gathering of data for the two types of evaluation.

BACKGROUND

Evaluation was defined by Hadji (1995) as the formulation of a value judgment on a given reality that is the object of the evaluation. More precisely, evaluation is the consequence of ascribing meaning to facts, data, and information associated with that reality. The judgment is generally based on a definition of suitable criteria and on the identification of the quality models used as a reference.

In education, a distinction is usually made on the basis of the object of the judgment: when the focus is on changes in individual competences, we talk about learning *assessment*, while if the object of judgment is the learning system, the teaching methods and the learning resources, the term *evaluation* is generally used (Ellington, Percival, & Race, 1993). When looking at the evaluation activity from the point of view of its goals, another distinction is usually made: *formative* evaluation aims to obtain both general and detailed information in order to improve the object of evaluation, while *summative* evaluation aims to formulate a comprehensive judgment on the object to be evaluated, often with certifying purposes. In accordance with these different goals, formative evaluation is usually carried out *in itinere*, that is, during the learning process, so that any problems are identified and dealt with as early as possible. Summative evaluation, on the other hand, is usually carried out at the end of the learning process, or at particular stages where a global judgment of the results is needed. In spite of this connotation of summative evaluation, it may also be based on data that has been collected during the learning process, not just at the end.

The above-mentioned terms and concepts have been used for over 50 years in both face-to-face and distance education (Bloom, Hastings, & Madaus, 1971; Scriven, 1967). The meanings of the terms have remained basically unvaried while the methods used to carry out evaluation and assessment continue to undergo major changes due to the evolution of learning theories, methods, and techniques. According to constructivist learning theories, for example, learners should be actively and increasingly involved in formative evaluation practices and consequent decisions in order to promote the metacognitive and self-regulation skills needed for effective personal and professional development. It is for this reason that evaluation strategies are being increasingly integrated into the learning process, and self-evaluation and peer evaluation are frequently practiced along with hetero-evaluation (Ranieri, 2005).

Although according to the above definitions, the distinction between assessment and evaluation is quite clear-cut, the two concepts have several points in common, both in theory and in practice. First, the evaluation of learning outcomes, or assessment, is of paramount importance in the evaluation of the quality of the educational process. A second correlation derives from the considerable overlap of both the methods and the data generally used for the two kinds of evaluation. According to Moore (1999), the relationship between evaluation and assessment lies mostly in the "monitoring" process. This is particularly true in the CSCL field, where the use of computers as mediators of communication between individuals allows us to record not only the interactions between participants, but also any event that is regarded as relevant for tutoring, evaluation, assessment, or research purposes.

EVALUATING A LEARNING SYSTEM

In order to evaluate a learning system, a systematic study should be carried out to produce a value judgment on its *efficiency*, its *effectiveness*, or any other aspect deemed relevant. This normally includes the collection, analysis, and interpretation of information on its various aspects (Thorpe, 1993), such as the quality of learning materials, effectiveness of the tutoring, efficacy of the collaboration between the members of the virtual community, as well as the suitability, user-friendliness, and efficiency of the tools used for synchronous and asynchronous communication.

The evaluation of the *efficiency* of a teaching program or of a single course focuses on organizational aspects and on issues related to the cost-benefit ratio of the considered system, where costs and benefits are not considered solely from a financial standpoint. Indeed, costs can also be regarded from the point of view of investments in human resources and learning materials, while benefits usually include educational and social outcomes. The evaluation of the cost-benefit ratio of a learning program is therefore quite complex and involves political, social, economic, and educational considerations (Phillips, 1998). It is worth pointing out that this ratio is often studied by means of a comparative approach aimed at determining the conditions which make one method more suitable than another from the point of view of the "return on investment."

For example, first and second generation distance education would seem preferable to face-to-face education as the number of students increases. This is because the fixed costs of a large-scale production of learning materials are offset by the variable costs, which increase more slowly than those of traditional education. On the other hand, face-to-face and online education have similar trends as far as tutoring costs are concerned, since in third generation distance education, they are directly proportional to the number of students (Trentin, 2000).

The evaluation of the *effectiveness* of a learning event is a key factor in the development of e-learning initiatives and deeply affects their design since it provides information on the adequacy of the instructional design with respect to its objectives. The evaluation process can also lead to reflection and revision of the educational objectives, as it may reveal a divergence between the latter and the learners' expectations and/or the social or training needs which the course was supposed to meet.

Evaluation of effectiveness also means understanding how much learning (intended as a modification of students' competences) has really occurred. However, it should be noted that formative evaluation of a course goes beyond the assessment of students' learning. For example, another aspect usually covered in the evaluation of a learning event is the degree of student satisfaction. This is not necessarily correlated with learning; yet it is a useful source of information for at least two reasons. The first is that a pleasant approach motivates students and predisposes them to face possible difficulties in a positive manner. The second is that, at least for adult students, positive feedback often mirrors the conclusions of a critical reflection on the educational process.

Typically, student satisfaction about a learning event is ascertained through interviews or questionnaires aimed at recording their opinions on the course and its components and their perceived satisfaction compared to their initial expectations. Hence, determining whether the educational objectives have been met and performing a survey of the participants' opinions on the learning event are both necessary in order to carry out formative evaluation of a training event. Together, they provide a reliable picture of the strengths and weaknesses of the learning initiative in itself, although they cannot predict the long-term consequences that the course will have on the organizational and social context where the trainees are expected to put their achievements into practice.

ASSESSING STUDENT LEARNING

As for any value judgment, learning assessment is strictly dependent on the choice of the evaluation criteria. This choice is normally made by the designers of the learning event and is obviously affected (as are all educational strategies adopted in the learning process) by the meaning given to the word "learning." For example, according to behaviorist theories, learning means acquiring the ability to carry out tasks or show behaviors which are considered correct and are defined as the objectives of the learning process. In this view, assessing learning means to evaluate whether and to what extent students can produce the desired behavior. This view led to much emphasis being placed on observable results or products, while the processes through which these outcomes are produced and the importance of the learning context were neglected (Macdonald, 2003). In practice, the behaviorist approach has produced a widespread use of evaluation tests which require skills belonging to the lower part of Bloom's taxonomy (Bloom, 1956; Trinchero, 2006).

According to sociocultural constructivist theories, on the other hand, learning is the result of a personal process of knowledge construction, heavily based on dialogue and negotiation with peers and affected by the context, the culture, and the background of the individuals involved (Kanuka & Anderson, 1999). In this view, learning assessment should not focus solely on the attainment of a set of skills (i.e., the learning outcomes) associated to the learning objectives but should also include the appraisal of the whole process that led to those outcomes.

Since the 1990s, much attention has been given to the development of *competences*, that is, higher order abilities belonging to the top levels of Bloom's taxonomy. According to Delors (1996) and Pellerey (2004), in order to become a *competent* individual, it is necessary *to know* (acquire factual knowledge), *to know how to do* (acquire skills), and *to know how to be* (which involves affectivity, motivation, social attitudes, values, and beliefs). The evaluation of the latter, considered the most important component of competence, requires the involvement of the students in authentic, situated problem solving or inquiry learning activities such as those usually proposed in CSCL environments. As discussed in the next section, the features of CSCL systems make them particularly well suited to assess competences with a process-oriented approach, rather than a product-oriented one.

MONITORING AS A COMMON DENOMINATOR BETWEEN ASSESSMENT AND EVALUATION

Monitoring consists of a constant and continuous activity of control and regulation of the learning process with four main objectives:

- Facilitation of the learning process as a whole by fostering participation, settling conflicts, encouraging socialization, and guiding the group to the goal by taking into consideration, at all times, the needs of the learners;
- Formative evaluation of the learning system, collecting information about how well it worked and what kind of learning dynamics it generated;
- Assessment of individual and group learning by collecting qualitative and quantitative information about the learning outcomes both *in itinere* and at the end;
- Research based on data concerning the learning dynamics generated by the course.

In CSCL, monitoring is normally performed by the tutors. In this task, they are facilitated by the fact that interactions are usually traced by the communication system and their analysis is often automated by tools which are more or less integrated in the e-learning environment. Nevertheless, monitoring usually implies a considerable workload, particularly in the case of large student cohorts. In order to make monitoring more effective, it is advisable to decide what information should be collected prior to the learning event and to set up methodological tools that make it less heuristic and more systematic. Careful design of the monitoring process also allows the development of software tools for data collection and data processing.

Monitoring usually aims to collect information of both a qualitative and a quantitative nature. To gather this information, it is necessary to identify indicators of the relevant aspects of the learning process. The most frequently used indicators in CSCL refer to students' active participation (such as writing messages, uploading documents, participating in chats, etc.) and passive participation (such as reading messages, downloading documents, etc.). Quantitative indicators of participation include the number and duration of sessions for each participant, the number of messages sent and read by each of them, the number of chats they participated in, and so forth. Content analysis of interactions can produce quantitative indicators of qualitative data, such as quality of collaboration (Pozzi, Manca, Persico, & Sarti, 2007), self-regulation (Giannetti, Dettori, & Persico, 2006), social presence (Gunawardena, Lowe, & Anderson, 1997), and so forth. The ensemble of these techniques clearly makes the shift of emphasis from the product to the process of learning possible and feasible. Product evaluation still occurs by means of traditional intersubjective evaluation techniques applied to essays and other artifacts produced by the learners.

It is interesting to note that, in many online courses, monitoring is used to inform not only formative assessment and evaluation, but also summative assessment. It is in fact quite frequent for tutors to take participation into consideration for the final assessment of learners. This approach does have some drawbacks, however. First, because learning should allow for the learners to make "mistakes," put forward naïve theories or consider wrong hypotheses, and this should not negatively influence summative assessment. Second, because if students are aware that summative evaluation takes account of what they write in their messages, some of them might be inhibited by feelings of inadequacy or fear of affecting their marks. Third, because this kind of summative evaluation could penalize those who cannot participate in the learning event for reasons that are independent of their will. In principle, the summative evaluation should consider each learner's results regardless of how they were obtained. On the other hand, not to use information from monitoring of online participation would hinder the tutor's role and discourage learners from participating. In fact, they would realize that their work and commitment to the online activities are not taken into consideration for the final evaluation.

A possible solution to such a contradictory situation is to have the quantity and quality of participation positively affect summative assessment. Little or poor participation should not influence summative assessment in negative terms, therefore allowing for alternative learning paths. In this way, summative and formative assessment can be integrated with the additional advantage that students participating online are informed of their results throughout the course.

CONCLUSION

Matching the needs of the learning context with the principles put forth so far is not easy. CSCL environments, however, make this endeavor easier thanks to a robust kernel of monitoring methodologies and tools that have been developed to support tutoring, assessment, evaluation, and research activities. Shifting the focus from knowledge and skills acquisition to competence development is heavily influencing the way learning processes are planned, designed, and evaluated.

For example, the development of metareflection and self-regulation abilities has become a primary concern because these aspects are critical components of the desirable competences of citizens of the "knowledge society." To achieve these aims, many online courses include targeted activities that entail the use of educational strategies such as peer review, role play (Persico & Sarti, 2005), scaffolding and fading tutoring techniques (Brown, Collins, & Duguid, 1989; Wood, Bruner, & Ross, 1976).

This brings about several major changes in how assessment and evaluation are carried out. For example, many online courses which adopt hetero-directed evaluation rely heavily on the tutor's role (Swan, Shen, & Starr, 2006). In fact, the tutor's continuous monitoring of learning dynamics allows for close integration between educational activities and evaluation strategies. This integration ensures that the final evaluation is not based merely on facts and notions but rather on more complex skills, such as solving complex multidisciplinary problems, creatively transferring solution strategies to new contexts, formulating and verifying hypotheses, choosing and discussing appropriate inquiry methods, and sharing and negotiating knowledge through participation in a virtual community.

Another important change is that summative and formative evaluation are partly based on the same methods. They consider both the process and the product of learning and allow for flexible learning paths as well as personalized assessment methods. Even the principle that assessment methods should be the same for everybody is somewhat undermined. Thanks to these changes, it is now possible to pursue and assess the development of complex competencies for which there is no one objectively correct solution but many possible informed, creative, and expert approaches.

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KEY TERMS

Bloom's Taxonomy of Educational Objectives: The American psychologist B.S. Bloom and his co-workers compiled a set of taxonomies of learning objectives, classified into three broad "domains": the cognitive, affective, and psychomotor domains. The most famous is the taxonomy proposed for the cognitive domain where six levels are identified, ranging from the simple/concrete to the complex/abstract. They are knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom,1956). According to Bloom, the six subdivisions should not be regarded as rigidly distinct or mutually exclusive, but rather as a continuum spanning the whole domain (Ellington et al., 1993).

Competence-Based Education: In the 1990s, the definition of learning outcomes in instructional design saw a radical shift of attention from the specification of behavioral objectives to the formulation of the aims in terms of competences to be developed. Competences include skills and knowledge needed to adequately perform identified jobs and tasks, but they also comprise higher level abilities and social attitudes that are considered important in a given context or profession. These aspects cannot easily be measured through traditional examinations, let alone tests. However, evidence of competences can be collected from self-evaluation, peer evaluation, and observation by others.

Formative Assessment: Its purpose is to improve the quality of student learning rather than judging or grading students. For this reason, it is generally carried out during (or even at its beginning) of the learning process. Formative assessment provides diagnostic information for teachers and students to make the necessary adjustments to the teaching and learning process, including the use of alternative instructional approaches or the provision of more opportunities for practice.

Formative Evaluation: "Typically conducted during the development or improvement of a program or product (or person, and so on), it is conducted, often more than once, for in-house staff of the program with the intent to improve. The reports normally remain in-house; but serious formative evaluation may be done by an internal or an external evaluator or preferably, a combination; of course, many program staff are, in an informal sense, constantly doing formative evaluation" (Scriven, 1991).

Summative Assessment: It aims to produce a comprehensive judgment on the learning outcomes of an individual student. Typically, summative assessment is quantitative and uses numeric scores or letter grades.

Summative Evaluation: Provides information on the quality of the learning system with particular reference to its ability/suitability to achieve its objectives. It usually produces a global judgment of the system, considering all of its components and taking a very general point of view. However, it may also focus on one particular aspect of the system. For example, summative evaluation of the learning outcomes or summative evaluation of students' acceptance.

Three Generations of Distance Education: In the literature, three generations of distance education have been identified (Garrison, 1985; Nipper, 1989). The first generation mostly involved individual learning and entailed the delivery of printed material to the students by mail. Communication between learner and tutor was based on a one-to-one model, and it entailed a very slow, sparse exchange of documents. The second generation was based on the use of multimedia teaching materials including videos, radio programs, open TV, cable TV, and educational software. These learning resources could be delivered via mail or through specialized telecommunication channels. In this case, tutor–student communication was based on a one-to-one or one-to-many model. The third generation, also called online education, takes full advantage of computer mediated communication systems and is heavily based on virtual communities and collaborative learning strategies. In this case, communication is based on a many-to-many model.

Semantic Web Adaptation

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INTRODUCTION

The rate of growth in the amount of information available in the World Wide Web has not been followed by similar advances in the way this information is organized and exploited. Web adaptation seeks to address this issue by transforming the topology of a Web site to help users in their browsing tasks. In this sense, Web usage mining techniques have been employed for years to study how the Web is used in order to make Web sites more user-friendly.

The Semantic Web is an ambitious initiative aiming to transform the Web to a well-organized source of information. In particular, apart from the unstructured information of today's Web, the Semantic Web will contain machine-processable metadata organized in ontologies. This will enhance the way we search the Web and can even allow for automatic reasoning on Web data with the use of software agents. Semantic Web adaptation brings traditional Web adaptation techniques into the new era of the Semantic Web. The idea is to enable the Semantic Web to be constantly aligned to the users' preferences. In order to achieve this, Web usage mining and text mining methodologies are employed for the semi-automatic construction and evolution of Web ontologies. This usage-driven evolution of Web ontologies, in parallel with Web topologies evolution, can bring the Semantic Web closer to the users' expectations.

BACKGROUND

Web Usage Mining

Web usage mining has a wide variety of applications. User profiles can be created for use in Web personalization. Information can also be extracted that details how a Web site can be reorganized to better facilitate users' navigation through it. In e-commerce Web sites, the results of Web usage mining can be used to improve sales. Analyzing user access patterns can also help when targeting advertisements to specific groups of users.

Srivastava, Cooley, Deshpande, and Tan (2000) divide Web usage mining into three stages:

i. Preprocessing
ii. Pattern discovery
iii. Pattern analysis

Preprocessing consists of converting the usage, content, and structure information contained in the various available data sources into the data abstractions necessary for pattern discovery. Usage preprocessing involves the identification of users and their visiting sessions. In order for this to be accomplished, several difficulties need to be overcome. For example, proxy servers hide the actual IP addresses of the machines that are using them, thus making user identification problematic. A user that uses more than one browser, even on the same machine, will appear as multiple users. Tracking repeat visitors can also be complex if a user uses different machines.

Content preprocessing consists of converting the text, image, scripts, or multimedia files into forms that are useful for the Web usage mining process. This often involves the application of content mining techniques, such as classification or clustering. For instance, a classification algorithm could be used to limit the discovered patterns to those that contain page views about a certain subject. Similar to the preprocessing of the site's content, structure preprocessing regards the extraction of the site's structure for use in the mining procedure. The hyperlinks of each Web page build the structure of the Web site. Most Web sites have nowadays an utterly dynamic topology, thus presenting a different structure to different users. This characteristic should be considered during the structure preprocessing phase.

The preprocessing stage is followed by the discovery of traversal patterns from the user access data. Traversal patterns reveal the way a user navigates through the site during each session. Clusters of users can be discovered through clustering of similar traversal patterns. Moreover, association rules can be applied to the pages accessed during a session, independent of their ordering. Examples of association rules that were extracted from an IBM analysis of the Web logs of the Official 1996 Olympics Web site (Elo-Dean & Viveros, 1997) are:

- 45% of the visitors who accessed a page about Indoor Volleyball also accessed a page on Handball.
- 59.7% of the visitors who accessed pages about Badminton and Diving also accessed a page about Table Tennis.

The percentages mentioned in both association rules are called confidence. Confidence can be defined as the number of transactions containing all of the items in a rule, divided by the number of transactions containing the rule antecedents (Cooley, Mobasher, & Srivastava, 1999). Additionally, temporal relationships among data items can be discovered, such as the following (Cooley, Mobasher, & Srivastava, 1997):

- 30% of clients who visited the '/company/products' page had done a search in Yahoo within the past week on keyword w.
- 60% of clients who placed an online order in the '/company/product1' page also placed an online order in the '/company/product4' page within 15 days.

Depending on the purpose of the mining, a traversal pattern may contain backward traversals. Backward traversals consist of references of pages earlier visited. Studying backward traversals can help discover missing hyperlinks, which if added will reduce these traversals, thus making navigation paths shorter and more convenient for the users. A pattern's accesses can also be restricted only to contiguous ones, which can be used for prefetching and caching purposes. A frequent pattern is maximal if does not contain any frequent subpatterns. This can reduce significantly the number of meaningful discovered patterns.

Pattern analysis is the last stage of the Web usage mining process. The patterns that have been produced are reviewed, and useful information is extracted from them. Knowledge query mechanisms, similar to structured query language (SQL), can be used to filter out the patterns. Another approach involves the use of data cubes and OLAP operations. Visualization techniques, such as graphing patterns or assigning colors to different values, can also be utilized to highlight interesting trends in the data. Last but not least, content and structure information can be used to filter out patterns containing pages of a certain usage type, content type, or pages that match a certain hyperlink structure.

Numerous approaches to Web usage mining have been followed, targeted to a wide range of applications. Chen, Park, and Yu (1998) and Nanopoulos and Manolopoulos (2000) have introduced the concept of using the maximal forward references to break down user sessions into transactions for mining access patterns. Yang, Pan, and Chung (2001) have proposed an efficient hash-based method, HMFS, for discovering the maximal frequent itemsets. Spiliopoulou (1999) has presented an algorithm for building aggregating trees from Web logs, then mining the Web access patterns by MINT mining language. (Cooley et al. (1999) have provided a query language on top of external mining software for association rules and for sequential patterns. Another query language for extracting navigation patterns, called MiDAS, has been proposed by Buchner, Baumgarten, Anand, Mulvenna, and Hughes (1999). Xiao and Dunham (2001) have investigated techniques to discover frequently used contiguous sequences of page references, which they call maximal frequent sequences (MFS). They have also developed an algorithm called online adaptive traversal (OAT) pattern mining, to mine MFS. Xing and Shen (2004) have proposed two algorithms, user access matrix (UAM) and preferred navigation tree (PNT), for mining user preferred navigation patterns.

Web Adaptation

Several Web adaptation systems have been developed over the years, mainly based on Web usage mining techniques. The WebWatcher system (Joachims, Freitag, & Mitchell, 1997) suggests links that may interest a user, based on other users' online behaviour. The system is implemented in the form of a proxy server. Each user is asked, upon entering the site, what kind of information he is seeking. Before he departs, the user is asked whether he has found what he was looking for. His navigation paths are used to deduce suggestions for future visitors that seek the same content. These suggestions are visualized by highlighting existing hyperlinks.

The Avanti project (Fink, Kobsa, & Nill, 1996) tries to predict the visitor's final objective as well as her next step. A model for the visitor is built, based partly on the personal information of the visitor and partly on information extracted from her navigation paths. Visitors are provided with direct links to pages that are probably the ones they are looking for. In addition, hyperlinks that lead to pages of potential interest to each visitor are highlighted. The suggestions are extracted with the use of association rules that are applied to the user's model.

A drawback of both the WebWatcher and the Avanti approaches is that they require the active participation of the users in the adaptation process, by asking them to provide information about themselves. On the other hand, Footprints (Wexelblat & Maes, 1999) relies entirely on the navigation paths of the users. The navigation paths of all visitors are recorded and the most frequent ones are presented to the visitor. Additionally, next to each link, the percentage of people who have followed it is displayed.

Perkowitz and Etzioni (2000) have proposed a conceptual framework for adaptive Web sites, focusing on the semi-automatic creation of index pages from clusters of pages. They have developed two cluster mining algorithms, PageGather and IndexFinder. The first one relies on a statistical approach to discover candidate link sets, while the second finds link sets that are conceptually coherent.

The Semantic Web

Since January 2005, the Web has grown by more than 17 million sites, according to monitoring firm Netcraft. This figure exceeds the growth of 16 million sites seen in 2000 when net fever reached its most intense pitch.[1] Significant progress has been made in technologies for publication and distribution of knowledge and information on the Web. People add private, educational, or corporate content. Growth also comes from the rise in blogging, in which users write regularly updated Web journals on various topics. However, much of the published information is not organized, and it is hard to find answers to questions that require more than a keyword search.

The Semantic Web (Berners-Lee, Fischetti, & Dertouzos, 1999) means to address these problems by expressing Web data in forms that are machine-processable, in order to be more efficiently maintained by software agents, thus enhancing precision of search, as well as logical reasoning. The vision behind this concept can be summarized as "giving information a well-defined meaning, better enabling computers and people to work in cooperation" (Berners-Lee, Hendler, & Lassila, 2001).

Ontologies are a key enabling technology for the Semantic Web, since they offer a way to give information a common representation and semantics. Daconta, Obrst, and Smith (2003) distinguish three levels of ontologies: top, middle, and lower domain levels. At the top level, the ontological information represented concerns primary semantic distinctions that apply to every ontology. The middle level represents knowledge that spans domains and may not be as general as the knowledge of the upper level. Finally, the lower level represents ontologies at the domain or subdomain level. This is typically knowledge about domain-specific subject areas. While an ontologist can address the upper and to a certain extent the middle level, the domain expert is absolutely required for the construction and maintenance of the lower level.

Mikroyannidis and Theodoulidis (2005) distinguish between the domain ontology and the ontology of a Web site dedicated to a certain domain. A Web site ontology is strongly related to the topology of the site and is comprised of the thematic categories covered by the site's pages. These categories are the concepts of the ontology. Each Web page, depending on its content, is an instance of one or more concepts of the ontology. The concepts can be related to each other through a number of relationship types, representing the associations the concepts have according to the Webmaster's perception. Figure 1 shows the Web site ontology belonging to the University of Manchester School of Informatics (www.informatics.manchester.ac.uk). The ontology has been built considering the organization of the thematic categories as this is defined in the current topology of the site. The hierarchy's top level contains seven classes: School, Undergraduate Programmes, Postgraduate Taught Programmes, Postgraduate Research, Research, News and Intranet. These are the main thematic categories of the site. These categories

Figure 1. The School of Informatics Web site ontology

are then expanded to more specific concepts, which are represented by subclasses.

It should be pointed out that the Web site ontology is quite different from the domain ontology. The latter describes relationships between the concepts of a domain, whereas the first is based on the organization of the information found in a Web site. The ontology of a domain is usually more complex than the ontology of a Web site related to the same domain. However, the maintenance of a Web site ontology requires considerable effort and has to be performed on a regular basis, since the content of a Web site is constantly updated.

SEMANTIC WEB ADAPTATION

The Semantic Web is undoubtedly a remarkable advance in the area of information management. The magnitude of Web data necessitates the use of machine-processable metadata. Nevertheless, the Web users' needs and requirements should not be neglected in the process of building and maintaining the Semantic Web. Semantic Web adaptation utilizes traditional Web usage mining methodologies and extends them in order to address the ontological perspective of the Semantic Web. Apart from the topology of the Web, which is targeted in a conventional Web adaptation system, semantic Web adaptation also aims to the evolution of Semantic Web ontologies.

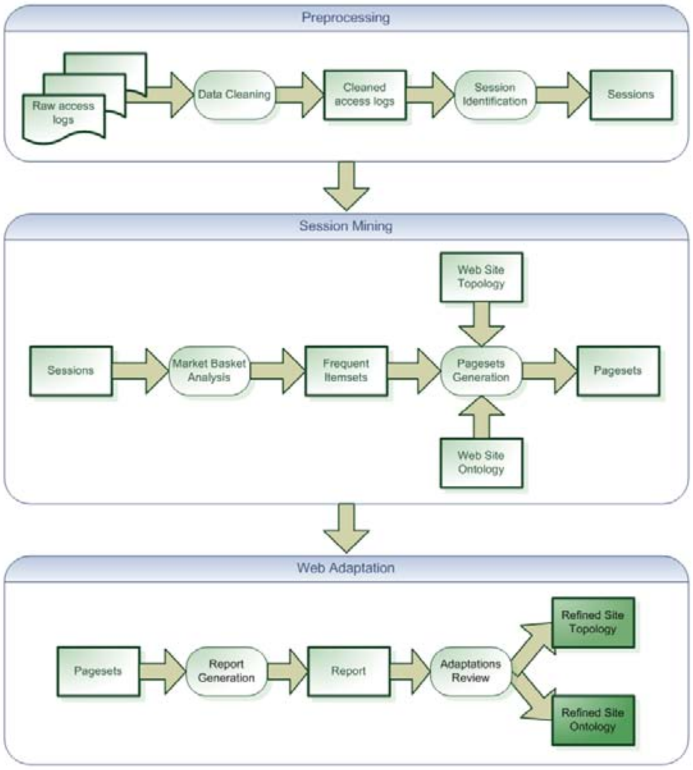
The Heraclitus framework (Mikroyannidis, 2004; Mikroyannidis & Theodoulidis, 2004, 2005) proposes the transformation of the Semantic Web based on Web usage data. Web usage mining and text mining are used for the extraction of knowledge from navigation paths and the adaptation of the physical and semantic structure of the Web. An implementation of the Heraclitus framework has been released as a suite of open source tools (http://heraclitus.sourceforge.net).

Architecture

Figure 2 presents the architecture of the Heraclitus framework. As it can be seen, the inputs of the adaptation process consist of raw access logs, the Web site topology and ontology. The whole procedure aims at the evolution of the topology and ontology of the Web site.

The adaptation starts with a preprocessing stage, during which the data stored in the raw access logs are cleaned and visiting sessions are identified. The sessions are then mined with the use of market basket analysis (Bodon, 2003) to retrieve frequent itemsets. These are then classified based on the Web site topology and ontology in order to produce page sets, that is, sets of pages that are frequently accessed together throughout the same session. During classification, each itemset is assigned its position in the topology and the ontology of the Web site. For the latter, automatic categorization is performed with the use of the support vector machines (SVM) algorithm (Cortes & Vapnik, 1995). SVM has been trained on the thematic categories that are defined in the concepts of the Webmaster's ontology. Each

Figure 2. Semantic Web adaptation architecture



page of the page sets is then assigned by SVM to one or more concepts of the ontology.

Based on the topological and ontological features of the page sets, a report containing proposals for the improvement of the Web site is generated. This report contains proposals for the insertion of shortcut links from source pages to target pages that are frequently accessed together but are currently not linked. It also contains proposals for the change of the appearance of popular hyperlinks. In addition, the report contains proposals for the evolution of the Web site ontology. After the proposed modifications have been revised by the Webmaster, they can be applied to the Web site. The site topology is then refined through the insertion of new shortcut links, as well as changes in the appearance of the existing ones. The ontology is also refined in a number of ways.

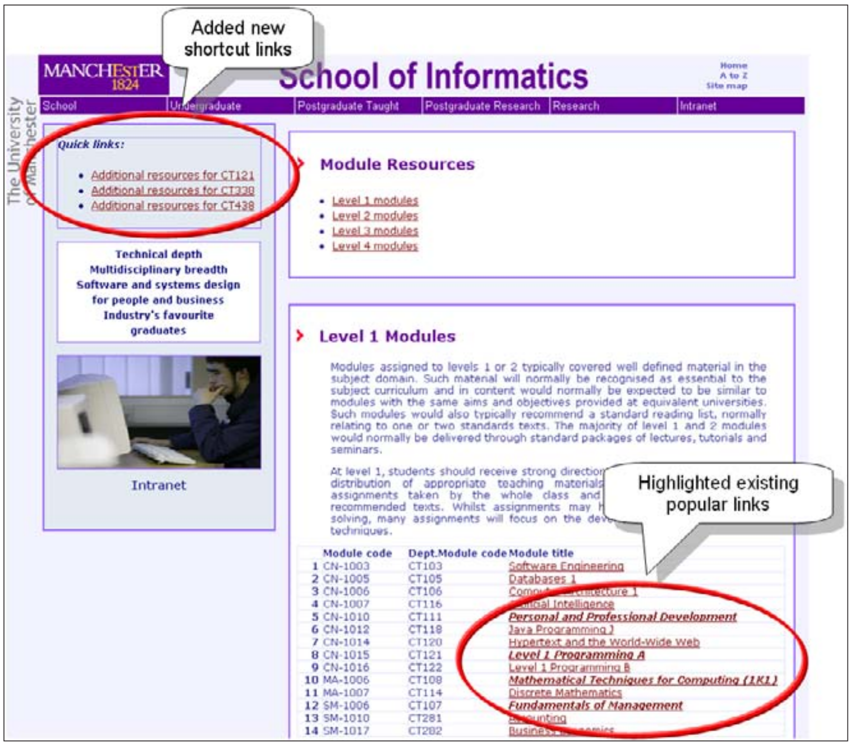
Case Study

The Web site of the School of Informatics at the University of Manchester (www.informatics.manchester.ac.uk) was used as a case study for the Heraclitus framework. The topology of the Web site was refined through the insertion of new shortcut links between pages that were not previously linked together, as well as through the highlighting of popular existing links. In addition, the Web site ontology was modified in several ways, based on the outcomes retrieved from the classified page sets.

More specifically, Heraclitus produced two sets of reports: shortcut links reports and highlighted links reports. Page sets of unlinked pages suggest the insertion of shortcut links between these pages, in order to achieve shorter navigation paths. From the page sets of linked pages, changes in the appearance of existing links can be extracted. For example, if an index page and some of its links comprise one or more page sets, then highlighting these links in the index page will provide valuable help to visitors.

Figure 3 shows an example of a modified Web page, according to the proposed Heraclitus adaptations. The page has been modified to facilitate the navigation of the users during the first semester. Shortcut links to popular courses of the first semester have been inserted in the left side of the page, under the title

Figure 3. Proposed Heraclitus adaptations in a sample Web page



"Quick links." Moreover, popular links that already existed, such as the hyperlink leading to the page of the "Personal and Professional Development" course, have been highlighted.

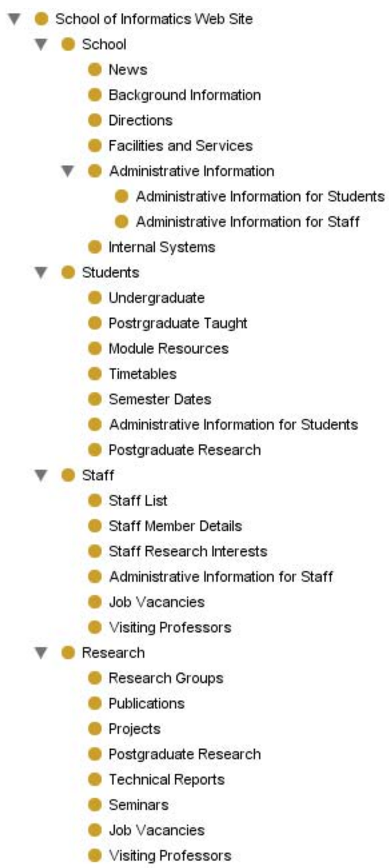
The Web site ontology was modified in several ways, based on the outcomes retrieved from the classified page sets. The resulting ontology, after the application of Heraclitus adaptations, is shown in Figure 4. Based on these adaptations, the content organization of the Web site was altered to better satisfy the needs of its visitors. First of all, new associations were discovered between concepts. These associations reflect the interests of the users, as documents belonging to these concepts are frequently accessed together. In particular, new associations were inserted between the following concepts:

- "Research" and "Students"
- "Research" and "Staff"
- "School" and "Students"
- "School" and "Staff"
- "Students" and "Staff"

Reorganization of the concepts' hierarchy was also performed. Further improvements included the creation of new categories, the removal of existing categories, as well as changes to the levels of hierarchy that the concepts belong to. For instance, the "Staff" concept was previously a subconcept of the "School" concept, which resided in the highest level of the ontology. It should be noted that the "Staff" concept has as instances all the Web pages that carry information about the staff members of the school. However, the high frequency with which this concept appeared in the page sets implies the significance that it has in the interests of the users. It would be thus appropriate to transfer this concept to the top level of the ontology, as shown in Figure 4. Based on the performed classification, the undergraduate and postgraduate programmes were grouped under the more general concept "Students." The "School" concept was also extended to include more subconcepts.

The ontology of the Web site was extended to include multiple instances of concepts or multiple subconcepts. The categorization of the Web pages that was carried out suggested that several pages belong to

Figure 4. Refined Web site ontology for the School of Informatics



more than one concept. Moreover, in some cases, Web pages and the corresponding concepts were categorized under different concepts than they previously were in the existing ontology. The Web site ontology should be therefore updated in order to reflect this fact. For example, the "Job vacancies" Web page, which corresponds to the "Job Vacancies" concept, was found to be an instance of both the "Staff" and "Research" concepts. The information contained in this page regards mainly research job posts and is also highly related to the "Staff" concept. This page was previously categorized only under the "School" concept. In the updated ontology, the "Job Vacancies" concept has been placed both under the "Staff" and "Research" concepts. The same modification has been applied to the concepts "Visiting Professors," "Administrative Information for Students," and so forth.

Finally, useful conclusions were deduced about the usage of the Web site. Particularly, the thematic category that was the first in the preferences of the users was, as expected, the "Students" concept. This concept contains all pages that support the school's modules, both undergraduate and postgraduate. This is not surprising, since most of the traffic is generated by the students. Second, in the users' interests comes the "Staff" concept. The "Research" concept is third, followed by the "School" category. These results can be used to enhance the performance of the server, for example, by the use of additional servers that will host the popular resources, or to promote the problematic concepts by making them more easily accessible.

CONCLUSION

The Semantic Web is undoubtedly a remarkable advance in the area of information management. The magnitude of Web data necessitates the use of machine-processable metadata. Nevertheless, the needs and requirements of the Web users should not be neglected in the process of building and maintaining the Semantic Web.

The Heraclitus framework approaches Semantic Web adaptation from a user-oriented perspective. Transformation of the Web topology and ontology is carried out having as basis the information retrieval tasks of the visitors. Web usage mining and text mining are used for the extraction of knowledge from navigation paths of the visitors. Practicing semantic Web adaptation on a real Web site has provided an insight in navigation difficulties of the users as well as in ways to overcome them.

NOTE

1 "Web enjoys year of biggest growth" (http://news.bbc.co.uk/2/hi/technology/4325918.stm), BBC News, 10 October 2005.

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KEY TERMS

Ontology: A representation of a certain domain, through the definition of concepts, relationships between concepts, and instances of concepts.

Semantic Web Adaptation: The process of transforming the topology and ontology of the Web in order to improve its usability.

Web Access Log: A listing of page reference data. Web access logs are created by Web servers in order to keep track of the requests that occur on Web sites by Web users.

Web Adaptation: The process of transforming the topology of the Web in order to align it with the preferences of the users, thus facilitating their browsing.

Web Mining: Mining data related to the Word Wide Web, such as the content of Web pages, intrapage structure, which includes the HTML or XML code of a page, interpage structure that is the linkage structure between Web pages, usage data that describe how Web pages are accessed, and user profiles, including demographic, registration information, or information found in cookies.

Web Site Ontology: An ontology whose concepts are the thematic categories covered by the pages of a Web site. Each Web page, depending on its content, is an instance of one or more concepts of the ontology. The concepts are related to each other through a number of relationship types, representing the associations the concepts have according to the Webmaster's perception.

Web Usage Mining: An application of data mining methodologies to Web access logs in order to discover trends and regularities in navigation patterns of Web users.

Social Networking and Personal Learning Environment

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INTRODUCTION

In social studies a *social network* is the set of relations that links people, through their interactions and familiarity of various kind. Today, however, social networking indicates a growing phenomenon, characterised by Web technologies that create and keep together groups of people on the basis of common interests. These tools (*social software technologies*) include for instance: blogs, *podcasts*, RSS feeds, social bookmarking, and offer new opportunities to promote collaboration, to assist conversations, to help in the sharing of knowledge, in work and learning contexts, both formal and informal. Although some of these tools are often used in LMSs, the main idea of this new approach is to consider the advantages coming from general purpose tools, widely available on the net, and characterised by an intrinsic vitality and spontaneity. In this context, also linked to a growing criticism of the current e-learning model, based on the extensive use of VLEs (*virtual learning environments),* new proposals oriented towards the definition of new models of Web spaces for personal learning (*personal learning environment* or *virtual learning landscape)* are being put forward. In these new systems the individual has a central place, in a network of resources and of social and friendly interactions that offer support on the emotional as well as on the cognitive level.

SOCIAL-SOFTWARE

In recent years, the availability of services and tools that enhance the creation of Web content by common users has grown enormously. Most of these "personal contributions" implicitly create interactions and connections among individuals on the net. It is not accidental that one talks of *social software,* referring to applications that make possible for people to interact and collaborate on line, particularly to create on-line communities. "Social software" is a term with a broad meaning, which includes systems and technologies used in various contexts: for this reason Terry Anderson (2005) has introduced the concept of e*ducational social software: "On line tools that support and encourage individuals to learn together with others, maintaining their control over time, space, presence, activities, identity and relationships"*.

In this sense, specific tools such as *wiki*s (1) *and blogs,* acquire particular relevance.

Wiki

A Wiki is a special Web site that allows multiple users, to create and edit pages in real time. It has become emblematic of collaborative authoring of hypertextual documents, because one of the most widespread use is to allow different people to work at a distance, concurrently, on the same body of pages interconnected via hyperlinks. The system keeps track of the modifications carried out and of previous versions (*versioning*) making it possible for a coordinator to accept or, if necessary, to reject the changes made by the collaborators. The use of wikis in e-learning is linked to collaboration, the feature that more than anything else distinguishes this technology. In all those instances in which there is a need to collectively write a text, wikis offer a valuable technical solution. Through the versioning mechanism it possible to follow the process of the elaboration of the text, whilst the hyperlink management system allows for the planning and the preparation of complex investigations. The ease with which one can create glossaries, dictionaries, terminological indexes or organized collections of thematic pages, makes it possible, in many subject domains, to develop very interesting research activities. Compared to the traditional face-to-face group work, wikis offer higher capabilities, because they allow a reflection starting from the very textual nature of the product, and the possibility to operate simultaneously amongst many individuals, remotely.

Teachers as well can find wikis very useful for working on projects, preparing articles, putting together course materials. A wiki is ideal, for instance, for collecting proposals and ideas for a conference or within a research project. However, the main strongness of wikis can also be seen as a weak point: the possibility offered to all to modify content. For this reason the majority of sites is somehow monitored to avoid intrusions, spam, and other abuses.

Blog

The term *blog* is the contraction of *Web log*, that is *"a log on the Web."* Blogs offer the possibility of writing quickly, without having any specific technical knowledge, notes, thoughts, reflections, texts of any kind, in the form of a Web page. The blog is probably the application that marks, more than any other, the transition from the *read only Web* to the *read and write Web*, where everyone can be an author, in addition to being a reader. The user thus writes new articles, whenever the user wishes, giving to the blog its characteristic appearance of a sequence of brief entries, similar to annotations in a diary. The blog is generally open to contributions from other users, who can add comments to the articles (if the author allows it), or can even be managed by many users, with writing rights.

The current use of blogs goes well beyond that of a "diary". The old "personal homepage" is increasingly giving way to blogs; journalists, public figures, politicians frequently use blogs, both as an extension of articles printed on paper, or as an alternative means of communication. It is a particularly significant phenomenon, because one notices how access to the production of Web content is available now to a large segment of users who were previously excluded. If the "personal Web sites" were generally a prerogative of ICT practitioners, today blogs are published mostly by nontechnical people.

It is very frequent, in addition, the contamination with other tools, such as *podcasting* and systems for archiving and sharing of digital photographs and videos (the new term videoblog or *vlog* has already been coined) (2).

The widespread use of these tools has given rise to information indexing and searching services inside what is now referred to as the *blogosphere*. With this "collective name" one indicates the entire blog community that increasingly takes the form of a *social network.* The majority of blogs are in fact densely interconnected: *bloggers* (3) very frequently read other blogs and link to them, reference them, post comments on them, thus forming a highly animated *agorà*. Blogs can thus become the true individual's on line "identity": according to a suggestive expression used by Granieri (2005), the blog is the stable "point of presence of a person". This is all the more true in personal blogs, when the blog is understood as a collection of content items, that range from professional, to spare time interests; differently from the "thematic" blogs, but still very interesting at the collective level, a multidisciplinary, personal blog can be a holistic representation of the individual, making it possible for him to participate (through cross links) in different social networks. One could hazard saying, that it is the very concept of identity that changes meaning on line, from "belonging to" or "being part of", it becomes being "linked to...".

Even in the field of formal learning the use of blogs presents some very interesting features: in the school blogs easily can allow teachers and students to become authors of log-books. This space can be understood also as a store of materials and exercises: an archive, or a course portfolio. Blogs can be an occasion for reflecting on lessons and a place for discussing and study in-depth certain topics.

This is the case of class blogs that enable teachers to actively exploit Internet potentialities, transforming students from passive users into authors.

Blogs have also an important role for providing the means to come into contact with experiences taking place "outside" one's own class. The coming into contact with research and didactic material developed by other work groups (for example by other schools) can become, in turn, an occasion for reflection and investigation, that teachers can suggest and organize.

In the informal learning context, instead, blogs represent an important space for the dissemination of ideas and research findings. Many researchers and scholars, in the ICT field in particular, use blogs to present and discuss the outline of their inquiry. Finally, other possible uses of blogs are linked to writing, as an introspective tool of investigation and, with its availability on line, to the dynamics of a social space (the blogosphere).

Tagging

Tagging is another example of the users' direct participation in the definition of Web content. In this case, however, it is not exactly concerned with the creation of content but, rather, of information relating to the classification of content. The question of classification and search for information on the Web became very early of crucial importance: search engines and *directories* (4) have been for many years the main point of access to the immense quantity of information contained in the Web. Search engines and indexers operate in a top-down way, implicitly imposing on users, in response to a query, their classification and their criterion of relevance (5).

Tagging completely reverses this approach: it is the single user that, with a *bottom up approach,* defines the link between the digital resources (Websites, images, films, music) and the terms used to describe them, which are exactly the *tags,* simple labels (single words or short sentences). Since tagging comes through the Web, above all through systems for the sharing of bookmarks called *social bookmarking,* the collaborative aspect emerges as well. This mechanism of spontaneous and collective categorisation done by means of tags is called *folksonomy* (a neologism from the root “folks”—people—combined with the word taxonomy; it indicates a system of classification (taxonomy) which is informal and managed autonomously by groups of people, who collaborate, spontaneously, in the organization of information. It is the opposite of the formal, a-priori, classification systems, in which the taxonomy is predetermined; it is also different from search engine indexing based on terms contained in the text: through folksonomy, meanings are continuously created by the users. The dishomogeneity and possible dispersivity are nonetheless the chief critical elements of folksonomy. In the absence of rules, each user is free to interpret the information tagging it freely. The lack of standards for the tag definition can lead to confusion: for instance a user can classify a resource using the singular, other the plural, there are generally no rules for using compound words or to represent hierarchical concept structures

Tagging is not an exclusivity of social bookmarking, for instance it is widely used also by blog authors to classify the articles and the pages they have inserted.

Systems based on tagging and social bookmarking, can thus be used as an alternative to normal search engines—still, this systems offers greater potentialities. For example, as the social bookmarking services keep track of who has created each reference and allows access to that person’s other bookmarks, a form of *connection* with others interested in different topics is established. Users find as well a “measurement” of the popularity of a given resource, since the number of users that have tagged and saved each link, found in the system, is always shown. The act itself of tagging has potentially a value, as it obliges the user to reflect on the meaning of the information he is saving. Each time that a user comes across a Web page that he thinks is interesting, the user can with a simple gesture, catalogue it, and share this information with others: it is apparently a inconsequential step but it has an enormous reach in the sharing of knowledge. Finally, the significance of resources on the Web is decided socially and transparently, subtracting the decision to experts and to the complex algorithms used by search engines.

SOCIAL NETWORKING

The concept of a “social network” stems from the studies in socio-psychology, sociology, and anthropology as early as the beginning of the ‘900. The studies on the analysis of the interactions between individuals in a community are more recent, such as the Social Network analysis that deals with the study of the structure of the network of interactions (of various kind) which is established amongst individuals (Scott, 1997). In recent years, in addition, the theory of connectivism is gaining momentum, as the theoretical basis to consider the net itself as a tool for learning (Siemens, 2004).

The online version of the social networks is known today by the name *social networking* and it refers to technologies and services available on the net that make possible for individuals to participate in real and proper virtual communities.

It is a multifaceted phenomenon corresponding more or less to the equivalent contexts of human relations, although the boundaries are a bit blurred:

- In the professional context, with the creation of communities of colleagues or thematic communities;
- In the context of free time activities, for friendly and sentimental interpersonal relations and the exchange of informal relations (6).

Web sites that offer social networking services do not normally use particularly innovative technologies. Basically the user, after signing up, is invited to insert as much information as possible about the user, in order to draft a personal profile that is as detailed as possible. One starts from personal details to arrive to interests and hobbies, passions, and preferences of any kind (this is especially so in communities dealing with spare time interests), or a detailed curriculum (for communities in the professional sphere) The next step usually consists in inviting other people to sign up for the service. Generally one contacts his friend or colleagues inviting them to do the same, in a sort of endless progression that, ideally, could include the entire world population. The mechanism of the social networking is in synthesis the following one: "I sign up, I invite my friends, who in turn invite their friends an so on, to arrive to create a wide network of friendships."

Through some services one can even make acquaintances, be means of algorithms, varying in their degree of sophistication, that manage to match up the different personal profiles.

To indicate the members of a community, one usually uses the term "friends": the members are thus linked by a bond of "friendship" that, nonetheless, is limited to those who are registered for the same service. Each one can thus belong to different communities, through the registration to different social networking Websites. There is no lack, however, of standardization proposals to universalize the concept of friendship, at the base of *social networking*, which is now currently limited to the services offered by individual Websites. An example is the proposal named FOAF (friend of a friend), a project that aims at creating documents in XML format aimed at describing people and their connections (http://www.foaf-project.org) (7).

Content: Aggregation, Use and Reuse

The protection of personal data and the attention to the safeguard of intellectual property rights are usually a major concern on the net. Surprisingly, however, in many new Web applications there is, instead, an increasing "opening up" of corporate Databases.

Striking examples are offered by Google Maps (that allow the re-use of maps to add commercial and/or other type of information, in a perspective of *georeferencing*), Ebay, and Amazon: they both allow public access to their DBs, to the extent that Web sites that use data coming from these two organisations, to provide added value services, have been created.

The possibility of allowing the use of information, or parts of the services normally offered, can be regarded as a strong, rather than a weak point. The trend is to invest in the fact that users, anyway, use the data (O'Reilly, 2005). A specific term for this concept has also been coined: this "remix" of content and services is called *mashup*. One could observe that the re use of images, films, news, graphics and other types of content, provided that the source is cited, is part of the ethics of the *hacker* (Himanen, 2003) by which concepts such as "freedom of speech", "freedom of action" and "self realisation", through one's own contribution to the creation of the net, are the parameters that since the 1980s populate the dreams of those who believe in the development of a *network society* free from monopolies and restrictions (8). The new network develops new rules. The Open Access Initiative, born from the Berlin Declaration in 2003, to promote free circulation and dissemination of human knowledge and of the cultural assets produced by the scientific community (9); projects like the already cited Free Software Foundation, active since 1985 aimed at the promotion of the user's right to use, study, copy, modify, and redistribute software (10), and finally the Creative Commons licences proposed by the nonprofit organization known by the same name, as alternatives to the traditional copyright, share this new spirit of the Web, seen as an open network based on the participation and the creative involvement of the users (11).

According to a research study of the *Pew Internet & American Life Project* on the use of Internet by young Americans (12-17 years old), 57% of them use the PC for "recreational" activities, such as the management of a Blog or the production of music and videos; 20% of them affirms, in addition, that they normally use materials produced by others, feeling free to download from the net and to manipulate texts, images, and audio to be recombined in their production (Pew Research, 2005).

An Application of Social Networking in Online Learning Systems

Starting from 2004, thanks above all to the activity of the British research community, the concept of *personal learning environment (PLE)* is gradually taking ground. Starting from the experiences and the studies on the e-portfolio, and including new life-long learning issues, with the PLE there is an effort to highlight even further

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the centrality of the individual. The acronym itself is not accidental: the assonance with VLE (*virtual learning environment*) is deliberate and wanted. The PLEs, in their being environments centred on the student, are contrasted to VLEs, considered institutionalised learning environments, that leave very little control to the student.

In 2005, Scott Wilson, published in his blog dedicated to the research in this field, a diagram that thanks also to successive re-elaborations, is now very well known in the blogosphere: In synthesis, a PLE (the “future of VLE”, at the centre in Wilson’s representation) should function as an “operational centre”, managed and controlled entirely by the student. The system should be able to interact with a series of external systems, partly related to formal learning activities (for instance the e-learning platforms and/or the institutional services provided by schools and universities attended by the student) and partly relating to social networking services and Websites in which the student could be registered and actively using, which represent the area of informal learning.

Some authors stress that it is important to keep the concept well separated from the technical system: there are different ways to implement a PLE, some are based on an ad hoc software, and others, on the contrary, use a mix of already available desktop software and Web services which, one hopes will develop further in the future (Attwell, 2006). The risk is that PLE might become in the end something very similar to the very thing they want to contrast (VLE): a new form of *walled garden* in which to isolate students from the rest of the

Table 1. PLE characteristic elements

Objective	Main tool / technology	PLE perspective
Learner-centred	Blog	It is the key concept of a PLE. From this point of view the environment is able to perform the functions of an e-portfolio, combined and/or implemented by means of a **blog**. The blog is seen as an essential element to overcome the difficulties that still limit the use on a wide scale of the e-portfolio. Differently from the latter, generally perceived as an “institutional” tool, a blog is considered a true “personal area”, informal, where no limitations are imposed on spontaneity. The success of informal environment shows how important it is to be able to choose the place and the way we wish to present ourselves. It is typical of blogs to be able to find different aspects of the author’s personality: alongside ideas and reflections related to one’s own study and profession, one often finds notes on interests, hobbies, and personal aspirations.
Informal learning	RSS	PLEs/blogs are able to integrate elements coming from informal learning situations on the net, for example the aggregation of RSS feeds coming from Websites that do not belong to formal learning systems. It is up to the user/owner, through appropriate presentation tools, to highlight the significant elements of the user’s own educational path, to be found both in formal and informal activities.
Collaborative learning	Social networking and social software	PLEs are open to social networking; systems and they support and integrate them. They are *natively* a typology of social software and foresee the possibility of sharing resources, including social bookmarking.
Micro-contents	RSS / Mashup	PLEs are based on microcontents. Their structure is based on, or inspired by, the model of a Web Service and the opening to any other system, in addition to the intrinsic orientation toward RSS as a powerful tool for the aggregation of content.
Open	Web Service	The *openness* is the chief feature of a PLE. If it is viewed as a technological system, it must interface with the greatest possible number of heterogeneous systems, for example with numerous LMS platforms, for the *formal* element and with public services of social software for the *informal* element.

external world (ibidem). In a more radical fashion, Blackall (2006) maintains that, after all, Iternet itself is a complete personal learning environment, and, therefore, no intermediate dedicated system is necessary.

The PLE Components

The basic matrix that comes out from the proposals at the theoretical level, but also from the early implementations carried out, is based on the *e-portfolio* model. The PLE are seen as an extension of the latter but revisited in the light of the social software.

The following table sums up the main functions attributed to PLE, in relation to some key objectives identified in the debate on this new vision of e-leaning.

CONCLUSION

The proposal of the *personal learning environment* presents itself as a "bridge-solution" between two worlds. Although highlighting in their name the contrast with institutional Virtual Learning Environments there is, however, the attempt to recuperate, as much as possible all the learner-*centered* elements present in the worlds of the e-learning, namely the e-portfolios, combined with the technologies and, above all, the practices of social networking: from the closed environments represented by the platforms that keep students "separated" from the real world, one moves instead to open environments that, on the contrary, can include connections with a VLE, but keep the door always open towards the external world, towards a Web rich with information, but above all, with links to people and not only pages. Blogs, social bookmarking, RSS, as "universal source" of information", seem to be the bases on which to build systems that are able to accompany people's real life, providing them with an on-line identity, an authentic telematic alter-ego

The debate has just started: for example it should not be taken for granted that PLE must be developed as true and proper applications, but it is equally true that it is not realistic to think that the system of VLEs can soon cease to exist. The very emphasis on informal learning can't be to the detriment of formal learning: schools and universities will probably continue to exist for a long time. What is certain is that "integration" is the key word for the future: tools, methodologies, and opportunities for learning.

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KEY TERMS

E-Portfolio: A collection of material in the guise of *digital artefacts* (documents, multimedia clips, links to resources, notes, etc.) related to a person's educational path. It can be referred to a specific course, or it can be seen as a permanent support for the individual, in the perspective of lifelong learning.

Folksonomy: A neologism that indicates the contribution from people (*folks*) in the definition of meaning and in the classification of information on the Web. It is contrasted to a-priori taxonomies complied by experts (for example in the library field).

Microcontets: In the perspective of *mashup*, the microcontent is the ideal unit for the re-use of information (MacManus e Porter, 2005). The Web is no longer viewed as a set of pages, but instead of even smaller units (for example a single post in a blog or a pod-cast).

Podcasting: The term podcasting groups all the techniques aimed at the production, the sharing and the use of audio/and or video material. The basic element of this technique is an audio or video recording—varying in the degree of expertise with which it is made, that can be used directly online or downloaded for listening or viewing off-line. This denomination is derived from the well known digital music reader Apple iPod; with the suffix "casting", derived from broadcasting, it comes to indicate a system for the transmission of audio material that can be listened to on many different devices, from the PC to a digital reader, to mobile phones.

RSS: RSS stands for *RDF Site Summary*, a format for the diffusion of content through the Web. From a technical point of view, RSS is based on the XML mark up language, well known for being the "foundation stone" on which the present Web could rise, separating content from presentation and graphical aspects. The RSS technology has as its fundamental aim the feeding on the Web of headlines of articles, news, links and, more generally, any sort of "what's new" of any site. It works as a kind of "announcement" that some new content has been added on a certain site. Blogs combine perfectly with RSS: each blog is equipped in fact with its RSS system that make it possible to keep up-to-date with the new articles that have been posted, without any need of visiting the Website directly. An alternative interpretation of the acronym RSS is *really simple syndication*: the term syndication is borrowed from the press (it would stand for "diffusion through a press office"). Leaving aside definitions and interpretations, the fundamental element is the means to disseminate "What's new" on different Web sites.

Social Bookmarking: Those that once were known as bookmarks, or preferred sites that each user used to save inside the user's own browser are now increasingly shared through specialised Websites. *Social bookmarking*, that i**s** in pooling one's own bookmarks, together with the tags freely supplied by the users. One of the main sites of social bookmarking is http://del.icio.us.

Virtual Learning Environment (VLE): In general, Web systems used for the management of courses in schools and in Universities. They are often also referred to by the acronym LMS (*learning management system*).

ENDNOTES

1 The fortune of Wikis is mostly due to the project *Wikipedia*, the "free " encyclopaedia compiled with contributions from common users (www.wikipedia.org) and based on a wiki system for the compilation of pages (www.mediawiki.org).

2 Amongst the most well known tools for the sharing of photographs stands out Flicker (http://www.flickr.com) or for the videos YouTube (http://www.youtube.com/. For sharing of audio Flickr (http://www.flickr.com) should be mentioned. Main Web sites for the aggregation and sharing of news items are: Digg (http://www.digg.com/), Slashdot (http://www.slashdot.com/).

3 A *Blogger* is the author/owner of a blog.

4 In the world of information searching on the Web two lines of action have gained ground: the first, a feature of "pure" search engines such as Google, based on whole text indexing of pages and the other, first proposed by Yahoo, based on directories, that is on a hierarchical classification

through numerous levels of categories and subcategories.

[5] It is well known that Google's fortune might also be due to the use of an almost secret algorithm to establish the relevance of a Web site (and therefore its prominence in the search results). The basic element for the calculation of the so called *page ranking* is the number of direct links to the page, but it is not the only element taken into consideration.

[6] One of the first services to be available online was Classmates (www.classmates.com), active since 1995 which made possible the search of old school mates. The true boom of social networking services, however, has come after 2001, with sites like Friendster (www.friendster.com) MySpace (www.myspace.com), Facebook (www.facebook.com) and LinkedIn (www.linkedin.com)..

[7] The aim of FOAF is to free personal details from the relational ones (that is the individual own social network) from the mebership to a certain community or service.

[8] The term *hacker is commonly* associated in common usage to computer crimes. On the contrary (according to a distinction that is progressively more difficult to contrast, that confuses them with *crackers*, the real computer criminals) the hacker culture is part of that wide movement, formed almost by students, to whom we are in debt for the many innovations and software that we use daily.

[9] http://www.zim.mpg.de/openaccess-berlin/berlindeclaration.html

[10] http://www.fsf.org/

[11] http://creativecommons.org

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'Stream of Training' Approach in Project Management Training

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INTRODUCTION

This article describes a training innovation that combines research on advances in information communication technologies (ICTs) and leading-edge training techniques. It also extends an evolution of traditional organizational change management (OCM) approaches and integrates technology more fully than current traditional change management practices. This new approach to training is based on concepts that have been utilized in artificial intelligence (AI) and machine learning. This approach merges traditional project communication and project training together to form a continuous 'stream of training' throughout the life cycle of the project. This technique is an advanced combination of both training and communication. Rather than utilizing a traditional linear training model, in this technique, training becomes a stream of learning incorporating pretraining communication (screen prints of new applications), 'push' training that can be electronically distributed through really simple syndication (RSS, also referred to as resource description framework, site summary, or rich site summary) to key stakeholders just-in-time (JIT) and electronic performance support systems (EPSS) that reinforce new process/technology changes. Some of the potential advantages of this approach are that it is less costly than providing separate communication and training functions and that utilizing an integrated or streaming approach to communication and training may lead to less conflict and confusion among key stakeholders about the current status of the project team. A discussion of the background and the benefits achieved by this approach are described in the following sections.

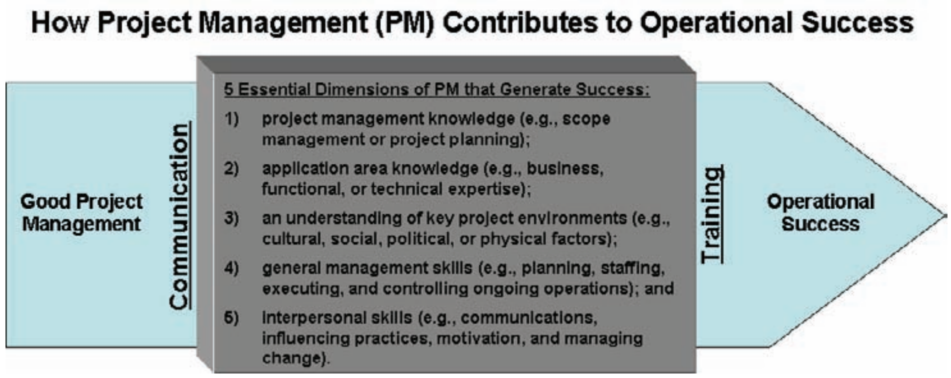
BACKGROUND

The idea of a 'stream of training' data or information evolved from the literature on artificial intelligence (AI) and machine learning (see references in Atkeson, Moorey, & Schaalz, 1997; Rosario, 1992; Utgoff, 1989; Utgoff & Brodley, 1990). In this research literature, a 'stream of training' or a continuous flow of data/information into a program permits learning to occur from the relationships present in the stream. The programs used in this research usually rely upon very sophisticated algorithms or models (such as a variant of the Hopfield net) to interpret these relationships. This stream or flow of data/information is possible today because of the speed of the processors and the capacity of the neural network (approximately 14% of the number of nodes in the network according to Goertzel and Troianov, 2005).

In the project management 'stream of training' approach, both training and communication are merged together. Separately, both training and communication are critical aspects of an overall project management approach to successfully implementing new systems or structures. Utilizing this approach, the project team combines training and communication into a steady stream of data/information to all relevant stakeholders throughout the life of the project.

The importance of good project management (PM) in an implementation project is obvious. In order for a project to be carried out in a logical and rational way, good project management is critical. However, good project management may also be responsible for the strategic differentiation of the organization. In a recent enterprise resources planning (ERP) conference, Ritchie (2005) stated that "project management has become the critical linchpin between strategy and operations" (p. 13). Often, the bridge between the successful

Figure 1. Project management-operational success model



implementation (thanks to good project management) and successful operational excellence (a strategic differentiator) is the communication and training received during and after the project (particularly on processes and applications). In support of this, Ritchie (2005) suggests five essential dimensions of project management expertise that will generate results: (1) project management knowledge (e.g., scope management or project planning); (2) application area knowledge (e.g., business, functional, or technical expertise); (3) an understanding of key project environments (e.g., cultural, social, political, or physical factors); (4) general management skills (e.g., planning, staffing, executing, and controlling ongoing operations); and (5) interpersonal skills (e.g., communications, influencing practices, motivation, and managing change). All of these areas of knowledge can be communicated or trained in order to assist the stakeholders and customers of implementation projects (see Figure 1).

In his book on project management, Cleland (1994) focuses an entire chapter on project communications. This early chapter lists the types of information and methods of communication that he suggests are important to a project's success, such as:

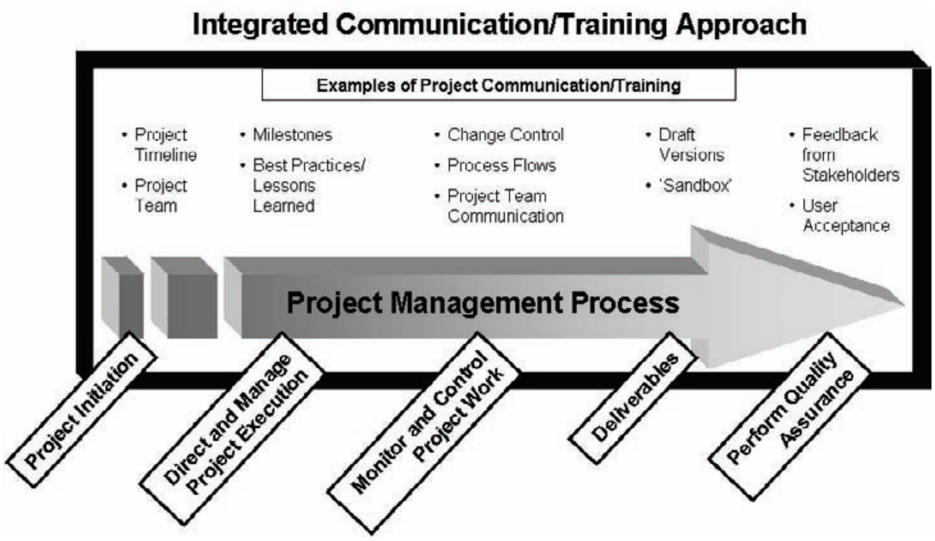
- Plans
- Policies
- Procedures
- Objectives
- Goals
- Strategies
- Organizational structure
- Linear responsibility charts
- Leader and follower style
- Meetings
- Letters
- Telephone calls
- Small group interaction
- Example set by the project manager

Many of these separate pieces of information (and the methods by which they are communicated) are utilized by members of the project team in training the recipients of the project deliverables. For example, a person developing training on a new system would utilize project plans, objectives, and goals as well as the results of project meetings as input to content for course curriculum. Because many of these sources of information and methods are found in both project communication and training (see Figure 2), it is logical to view them as an integrated part of the overall project management process.

Some examples and short descriptions of types of communication and training that can be combined in an integrated approach throughout the life cycle of the project include (from Figure 2):

- **Project timeline:** Communication regarding the project timeline is distributed to all relevant stakeholders
- **Project team:** The background and experiences of the project team are communicated with all relevant stakeholders
- **Milestones:** Milestone achievement, prerequisites, and other relevant data are shared with all relevant stakeholders
- **Best practices/lessons learned:** These are developed into frequently asked questions (FAQs),

Figure 2. Integrated communication/training approach



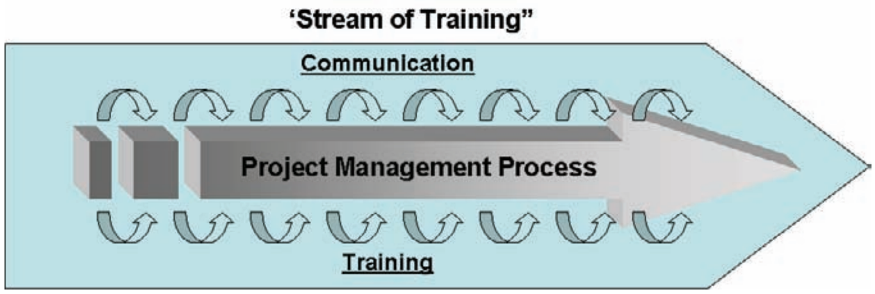
process improvements, and/or training content and then communicated or trained to relevant stakeholders

- **Change control:** Changes to the project timeline, scope, or team are communicated to all relevant stakeholders
- **Process flows:** The process workflows, changes, and/or improvements are communicated to all relevant stakeholders and/or developed into training materials for relevant users
- **Project team communication:** Project team communications (e.g., project team meeting notes) are distributed to all relevant stakeholders
- **Draft versions:** Draft versions of the applications or systems are made available to all relevant stakeholders
- **'Sandbox':** A beta version of the application or system is made available for training purposes
- **Feedback from stakeholders:** Feedback about the application and/or system is collected from users and communicated back to the project team/or and all relevant stakeholders
- **User acceptance:** User acceptance training, validation, and/or vetting occurs and any relevant data/information is collected and turned into FAQs, process improvements, and/or training content and then communicated or trained to relevant stakeholders

Therefore, because of recent advances in ICT, it is now possible for practitioners to adopt a 'stream of training' approach that combines project training and communication. Some of these technologies could include RSS, streaming digital media, Web-based training (WBT), and EPSS which is defined as 'the electronic infrastructure that captures, stores and distributes individual and corporate knowledge assets throughout an organization, to enable individuals to achieve required levels of performance in the fastest possible time and with a minimum of support from other people' (Raybould, 1997, p. 167). These technologies allow the training and communication to be continuously streamed throughout the life of the project. An example of this can be found in the model in Figure 3, which shows how both training and communication can flow throughout the project and utilize integrated data/information (listed above) created by the project team.

In a book by Dinsmore published in 1999, 14 principles are listed for successful enterprise project management. The thirteenth principle states: 'Communication in enterprise project management covers the spectrum from alignment of companywide goals on one end to interpersonal communication on the other." Similarly, this principle should apply to training. Enterprise projects need comprehensive ('cradle to grave') communication and training. Training should

Figure 3. 'Stream of training' model



not be considered just another function of the project or, even worse, simply a final deliverable. Imagine a scenario where a training course on a new application (for new entry level employees) did not incorporate information about the new processes (put in place by the project team) nor did it cover aspects of the new operating system or hardware (that were determined to be requirements or issues early on in the risk analysis performed by project team). This would most likely be a very unsuccessful implementation. In a best practices example, both training and communication should be integrated, comprehensive, just-in-time, and intertwined so fully that they cover the same source materials and tell the same story.

ADVANTAGES

One of the potential advantages of this approach is that it can decrease the costs of providing separate communication and training functions. From the literature on WBT, there is support for at least modest or possibly astounding cost savings, depending on how training dollars are currently spent (Cangero, 2000). Expanding upon this finding, Cangero (2000) suggests that typically WBT courses cost far less than the same course taught in a classroom setting (WBT eliminates the substantial additional costs of travel, lodging, and meals for students), and they have the advantage of providing a continuous 'stream of training' material to workers at their desktops. These same cost savings can be realized for project communication as well.

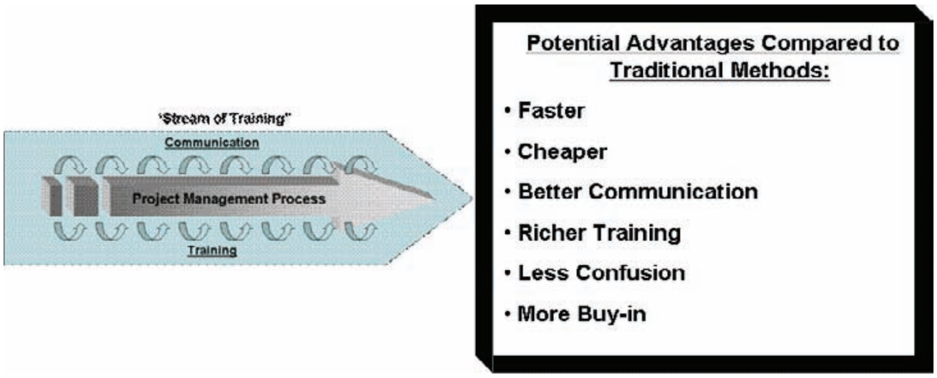
In addition, an integrated or streaming approach to communication and training may lead to less conflict and confusion among key stakeholders about the current status of the project team. In the book *Field Guide to Project Management*, Cleland (1997) suggests that there are eight project management functions that can be a source of conflict.

- **Scope:** What is to be done (results, products, and services)
- **Quality:** What measures, what steps to be taken
- **Cost:** Financial outcomes, savings, return on investment
- **Time:** Deadlines, resources, when complete
- **Risk:** What risks are accepted, avoided, deflected
- **Human resources:** What resources, what skills, availability, competency
- **Contract/procurement:** Cost, requirements/specifications, when, how, what, where
- **Communications:** When, how, to whom, contains what

Utilizing a streaming approach to both communication and training can reduce the amount of confusion and integrate project team data/information. In a typical project, communication may come from different individuals or groups depending on which PM functions are involved. In addition, there may be different information repositories in the various PM functions which may or may not be shared fully. In the traditional approach, this can lead to the perception of functional 'silos' within the project team itself (see Figure 4 for an example of the various functions). This can lead to a decrease in the effectiveness and efficiency of the project team's communication and training efforts.

In their book *Total Project Management*, Stallworthy and Kharbanda (1983) suggest that an area of project expense that is commonly overlooked and severely underestimated is pre-operational expenses. These are

Figure 4. Potential advantages of the streaming approach



expenses that occur in the operations area of product development prior to producing a product. They suggest that the training of both operational and maintenance personnel would be considered a pre-operational expense, as the personnel have to be trained before the plant goes 'live.' This can sometimes lead to a 'prolonged startup and commissioning period' which is sometimes hidden costs in the project (Stallworthy & Kharbanda, 1983, pp. 154-155). The integrated streaming approach can eliminate or reduce these costs as the training of personnel would occur during the lifetime of the project thereby reducing the amount of 'down-time.'

Some additional advantages that differentiate this approach from the traditional approach include:

- The initial screen prints and other project-level information are distributed to first-line staff employees so that their awareness and understanding of the application prior to 'go-live' are increased.
- The training is performed in a 'just-in-time' basis and is developed from project materials which allows for a quick turnaround of information and knowledge.
- This approach adds additional content and 'realism' to project team communications.
- This approach can also add to higher adoption rates and less resistance to change among stakeholders (thus relating to OCM as well).

Based on these potential benefits, project teams that have as their responsibility both the training and communication of project teams and end users should consider the integrated streaming approach. The advantages over the traditional approach to project communication and training are summarized in Figure 4.

FUTURE TRENDS

In the future, evolving technologies could lead to more seamless integration between training and communication, as well as human capital management (HCM), knowledge management (KM), and human resource information systems (HRIS). In the near future, the new skill sets that are developed by project team members will be tracked in HCM systems, and the best practices from the team will be tracked in KM systems which will in turn feedback to new project teams as integrated training and communication content (see Vequist & Teachout, 2006 for a review of HCM and KM integration). The project team members will be selected in advance from the HRIS system and given preproject streaming communication through digital devices (like personal digital assistants or cellular phones).

In a recent book chapter, Vequist and Dominguez (2006) found that there are five constructs that seem to underlie the fulfillment that some people experience being involved in project teams: autonomy (defined as the condition or quality of being autonomous or independent); career expectancy (defined as expecting that the outcome will assist them in their career); ownership (defined as able to take ownership or responsibility for outcomes); self-development (defined as the ability to learn from activities in a self-paced manner); and sociability (defined as giving the opportunity to enjoy the company of others). In the future, studies may find that the streaming approach to project communication and training may even lead to higher levels of satisfaction among project team members. The streaming approach could make the project team members feel as if they have more ownership of the project, and this approach may lead to higher levels of career expectancy and self-development.

CONCLUSION

In conclusion, based on the research and findings, it is suggested that the 'stream of training' approach should continue to improve upon some of the traditional, functional areas of PM. The streaming approach to project training and communication reflects technological improvements to the PM methodology and can lead to increases in the overall effectiveness and efficiency of project teams. In the future, it is possible that this improvement will involve other systems as well to form a continuum of streaming data and information that will revolutionize project work as we know it.

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KEY TERMS

Artificial Intelligence (AI): Generally accepted to mean intelligence as exhibited by a computer program or other artificial entities. This is an area of computer science dealing with fuzzy logic, intelligent behavior, machine learning and adaptation to new stimuli. Applications of AI systems are primarily found in military and commercial systems concerned with control, planning and scheduling, answering diagnostic and consumer questions, and handwriting, speech, and facial recognition. Closely aligned with robotics, it aides in the production of autonomous machines that can perform automated tasks requiring high levels of intelligent behavior.

Electronic Performance Support Systems (EPSS): These systems support a worker so that they will be more successful and productive in their work. It can be any type of electronic system that supports workers with flows of data and information. These systems are very important in the new age of work because workers have become inundated with data and information, and it is imperative that they learn how to organize and consolidate it quickly and accurately. The payback for EPSS lies in its ability to adapt, change, and evolve to meet the changing needs of workers who utilize these systems.

Enterprise Resources Planning (ERP): These are typically integrated systems that can provide the infrastructure for a wide range of processes including human resources, procurement/supply chain, call-center/sales-force automation, and financial/accounting. Usually this refers to packaged software provided by vendors such as PeopleSoft, SAP, Oracle, Lawson, JD Edwards, and Baan. The advantages of these systems are that they typically allow for improved enterprise application integration and are part of an overall business process reengineering (BPR) to improve the company's processes.

Organizational Change Management (OCM): Describes the multidisciplinary/ multidimensional process of managing change in an organization. Often involves understanding the communication flows and structures/processes that exist in the organization. Usually, the objective of OCM is to minimize the risk of failure of implementing the change by maximizing the collective efforts of all people involved in the change.

Project Management: A methodology undertaken by a project team and led by a project manager to minimize the risk of failure and maximize the chances of success in a project. The project team under the leadership of the project manager defines goals/targets, determines how to efficiently utilize project resources such as time, money, people, materials, systems, and so forth during the course of a project.

Really Simple Syndication (RSS): A relatively new format for distributing news headlines and other content on the Internet. Other names for RSS are RDF (resource description framework), site summary, or rich site summary, or really simple syndication. It is found on many Web sites, portals, e-zines, and electronic databases.

Web-Based Training (WBT): This is a form of computer-based education or training where the training material resides on the Internet and is accessible using a Web browser. This form of training typically incorporates multiple types of media elements into the content including text, graphics, animation, audio, and video. May be facilitated by a trainer or be in a self-directed, asynchronous format.

Strengthening the Knowledge-Base of Cities Through ICT Strategies

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INTRODUCTION

During the last two decades knowledge based development (KBD) has become an important mechanism for knowledge economies. In a knowledge economy information and communication technology (ICT) is extensively seen as a potentially beneficial set of instruments, which may improve the welfare and competitiveness of nations and cities. At present both public and private actors aim to exploit the expected benefits of ICT developments. ICTs offer unprecedented promise for social and economic development on all global, national, regional, urban, and local levels. This chapter seeks to investigate the potential of ICT strategies at both regional and urban levels, and in particular to shed light on various factors that influence urban ICT strategies in the public domain.

The chapter sets out to explain the KBD processes and challenges and opportunities in information acceptance and use in urban policy making. This chapter draws on providing a clear understanding on policy frameworks and relevant ICT applications of the Queensland Smart State experience.

The chapter is made of six sections. The first section following the introduction provides background information. The second section focuses on the KBD processes in Queensland. The third section offers a comprehensive analysis of the Queensland Smart State initiative, and it also identifies actors and goals of the agenda of Smart State experience. The fourth section reviews KBD and ICT applications and policies of the Queensland Smart State and Brisbane Smart City experiences, and their impacts on Brisbane's successful KBD. The fifth section discusses knowledge hubs and ICT developments within the Brisbane metropolitan area. Then the chapter concludes with conclusion and future trends section.

BACKGROUND

In the information era, sustainable economic growth and development is highly associated with knowledge economies (Metcalfe & Ramlogan, 2005). The term knowledge economy was first introduced by the OECD in 1996. A knowledge economy creates, distributes, and uses knowledge to generate value and gives rise to "a network society, where the opportunity and capability to access and join knowledge and learning intensive relations determines the socio-economic position of individuals and firms" (Clarke, 2001). Rapid advances in ICTs during the last two decades established the infrastructure that enables the knowledge economy to scale up. The main novelty of the knowledge economy consisted of the need to manage an intangible asset that, in contrast to material resources, does not depreciate through use but rather becomes more valuable the more it is used (Laszlo & Laszlo, 2006).

According to Buckley and Mini (2000) a city's knowledge economy is the economic wealth and well being that results from the effective investment in people and ideas that create an environment where information, creativity, goods and services are produced and exchanged, drawing on best practices. It requires a skilled labor force, up-to-date knowledge, effective use of technology (primarily ICTs), and broad city resources that foster a productive urban economy. In this process, communication, good governance and partnerships are developed with all major stakeholders.

KBD is a powerful strategy for economic growth and the post-industrial development of cities and nations to participate in the knowledge economy. It is a strategic management approach, applicable to purposeful human organizations in general (Carillo, 2002). KBD has two purposes: The first one is, it is a strategy that codifies technical knowledge for the innovation of products and services, market knowledge for understanding changes in consumer choices and tastes, financial knowledge to measure the inputs and outputs of production processes, and human knowledge in the form of skills and creativity, within an economic model (Lever, 2002). The later one is that, it indicates the intention to increase the skills and knowledge of people as a means for individual and social development (Gonzalez, Alvarado, & Martinez, 2005). KBD policies includes: developing and adopting the state of art ICTs, distributing instrumental capital, developing human capital, and developing capital systems (Carrillo, 2002).

To date, the structuring of most of the knowledge cities/regions has proceeded organically: in essence, as a dependent and derivative effect of global market forces. Urban and regional planning has responded slowly, and sometimes not at all, to the challenges and the opportunities of the knowledge city. Therefore, in recent years urban planning has consolidated its interest in the paradigm of post-modern social production under the rubric of knowledge based urban development (KBUD) (Yigitcanlar, Velibeyoglu, & Baum, 2008a). Planning sees KBUD as a new form of urban development for the 21st century that could, potentially, bring both economic prosperity and sustainable socio-spatial order to the contemporary city. The goal of KBUD is a knowledge city purposefully designed to encourage the production and circulation of abstract work (Yigitcanlar, Velibeyoglu, & Baum, 2008b). KBUD can also be regarded as a tool or an approach to nourish the transformation and renewal of a city into a knowledge city and its economy into a knowledge economy (Yigitcanlar, 2005).

KBD Possesses in Australia

Once Australia entered the information era and the new millennium, Australia needed to make a choice between two options for the continuum of her successful economy. The first option was competing as a low wage economy based on the excellent but now degrading natural resource base by reducing wages, living standards and environmental controls. And the second one was continuing with industries that are price takers (e.g., ICT, nanotechnology) in the global economy. Fortunately, Australia has chosen the later one, which is to be part of the emerging knowledge economy, an economy that has an emphasis on the use and dissemination of information as the basis for innovation, competitiveness and growth (Marceau, Manley, & Sicklen, 1997).

Mainly because of the high level of knowledge base, business research and development (R&D), government support for business R&D, total investment in knowledge, communication and electronic commerce and venture capital in many respects Australia is well placed to compete in the global knowledge economy. Australia's prime strengths revolve around the following three key factors (McKeon & Lee, 2001):

- A reasonable strong knowledge and technology base
- A number of competitive industries linked to that knowledge base
- A rapid process of adjustment to new global realities.

The KBD process in Australia comprises five interrelated components. These are: ICTs; information networks; new industry processes (including innovation, research and development, and technological diffusion); human capital; and capital accumulation through the privatization and commercialization of knowledge (Munro, 2000).

QUEENSLAND SMART STATE STRATEGY

In terms of overall economic measures, Queensland is an outstanding performer and has been Australia's fastest growing regional economy over most of the last decade. Economic growth in Queensland has exceeded that for Australia for about a decade, and Australia itself has been acclaimed as one of the fastest growing economies in the OECD (Greenfield, Hammond, Milsom, & Rayner, 2006).

In 1998, Queensland was developing an extensive knowledge infrastructure centered on nine universities, and research agencies. Queensland also had emerging capabilities in niche areas such as ICT, nanotechnology, neuroscience, forensics, sports science and eco-tourism, as well as continuing her competitiveness in food and agribusiness, aviation and aerospace, mining, marine and environmental technology industries. However, many of the developments were not coordinated and there was insufficient recognition of these sectors' potential to generate wealth. The Queensland Government recognized that greater levels of investment were needed to boost Queensland's knowledge infrastructure and take advantage of the State's potential. In August 2003, the Government released the Smart State strategy prospectus: Queensland the Smart State investing in science, research, education and innovation over the next five years. The prospectus outlined the Government's commitment to achieving the Smart State vision, stated the vision as *using knowledge to drive economic growth*, and charted future directions and new initiatives in nine key strategic areas (Queensland Government, 2004):

- Knowledge intensive economic growth
- Skilling up the labor force
- Science and technology (i.e., ICT) education
- Building scientific and research facilities
- Commercializing discoveries and innovations
- Harnessing smart science for the environment
- Managing the knowledge economy
- Government agencies to drive research and innovation
- Strategic partnerships.

The Smart State strategy comprises a number of initiatives for providing a stimulus to boost industry innovation and commercial capacity for greater global export and trade gains. Key initiatives for mobilizing the innovation process by providing support in converting ideas into results include (Queensland Government, 2005a):

- Innovation building fund
- Smart State research facilities fund
- Innovation skills fund
- Innovation projects fund.

Key initiatives for building the Queensland brand through expanding on strengths, successes and recognition to take Queensland to the world comprise (Queensland Government, 2005a):

- Smart ICT – to grow the ICT industry and exports
- Smart sector strategies – to grow priority industry sectors
- Aquaculture development initiative.

Key initiatives for making the right connections by investing in strategic alliances and networks include (Queensland Government, 2005a):

- Smart State Council – to provide advice on emerging trends
- International collaborations program – to support strategic alliances
- A virtual forum – to shape the future agenda.

As well as providing an immediate stimulus for innovation, Smart Queensland takes the long-term view by building Queensland's capacity as an innovative society. Investing in knowledge and skills requires new approach in learning and education that equips people with the knowledge, technology (e.g., ICT), skills and abilities necessary to succeed in an innovative society. Key initiatives in learning and education focus on (Queensland Government, 2005a):

- Smarter learning – assessing and reporting across all schools
- Smart classrooms – access to learning beyond the school grounds
- Smart academies – excellence in science, technology and creative arts.

Creation of new knowledge-intensive jobs and new skills are among the major requirements of the knowledge economy, therefore training and higher education system enthusiastic about innovative enterprise and partnership with industry is a must. Key initiatives in this area include (Queensland Government, 2005a):

- Modernizing the vocational and education training system – to deliver flexible and responsive training by using ICTs
- Smart State university internships – to assist students become work-ready
- Skilling solutions – a one-stop shop providing free training and career advice.

To achieve KBUD and being competitive in the global markets the Smart State strategy also aims to attract international investment and knowledge workers as well as improving its residents skills through training and providing incentives to Australian investors. Investing in diversity, creativity, connectivity and sustainability is another important aspect of creative knowledge regions. Therefore Smart Queensland aims to increase Queensland's appeal as a place to live, study, work and play, by creating a dynamic Queensland, building a community that cares for its people and fosters and celebrates knowledge and creativity. Key initiatives comprise (Queensland Government, 2005a):

- Business and skilled migration program – attracting knowledge workers
- Queensland multicultural festival and images of Queensland – the diversity
- Ideas festival – exchange of bright ideas.

Infrastructure (mainly ICT networks) is needed to be provided in order to strengthen connectivity of Queensland's firms, institutions and residents. Key initiatives in the provision of new infrastructure include (Queensland Government, 2005a):

- Streamlined development approvals process for ICT infrastructure
- Online telecommunications information portal for business and communities.

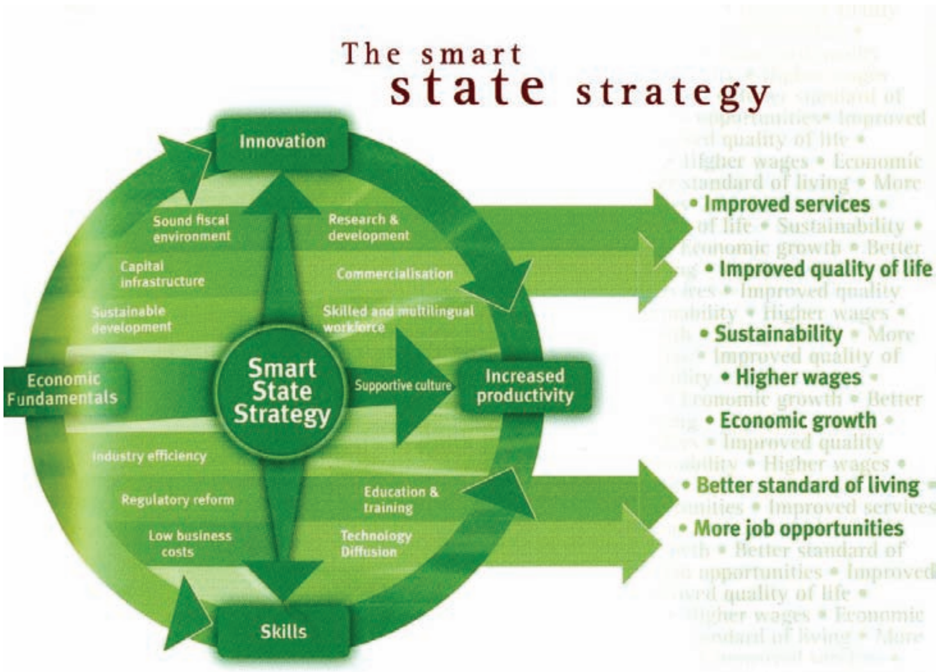
Sustainability and smart use of our natural resources is an integral part of the Smart State strategy and the following initiatives are supported (Queensland Government, 2005a):

- Sustainable natural resource development strategy
- International water center
- Innovative research to control cane toads.

The Smart State strategy is mainly about positioning Queensland economy as a modern knowledge economy, recognizing knowledge, science, technology, research, education, and innovation as key drivers of economic growth. It also aims to achieve KBD and KBUD through a wide collaboration between public-private-academia partnership and including all stakeholders and interest groups into the decision-making process as active actors.

Most of the initiatives have targeted enabling technologies as applications of enabling technologies are critical to the sustainability and globally competitiveness of Queensland's important traditional industries—such as agriculture and mining—based in the regions, and for the growth of emerging industries such as ICT, nanotechnology, biotechnology, smart materials, and aviation and aeronautics (State Development and Innovation, 2004). These initiatives and the Smart State strategy have a strong pushing power in positioning Queensland economy as a knowledge economy.

Figure 1. The Smart State strategy (Queensland Government, 2005a)



THE ROLE OF ICT IN KBUD IN BRISBANE

Brisbane is the capital of Queensland and the fastest growing state in terms of economy, urban development and population within Australia. Although there are few knowledge intensive industries located, and some limited KBUD initiatives are planned for Cairns and Townsville, most of the KBUD in Queensland occurs within the Brisbane metropolitan area.

The use of ICTs in interorganizational communication, in information sharing and data management is key to achieve cities' agendas, in terms of KBUD, delivery of services, and outcomes through social integration. Similar to Queensland's Smart State strategy Brisbane City has also adopted a 10 year Smart City vision aimed at addressing and promoting the following: information access; lifelong learning; the digital divide; social inclusion and economic development. The operationalization of Smart State and Smart City initiatives from one center for each promotes overall integration of various local and statewide e-governance initiatives. The city and the metropolitan region are well integrated in terms of service delivery, the infrastructure for which is underpinned by the telecommunications plans, with social integration addressed through the various initiatives. Integration is facilitated largely through a strong state government and city council—with a clear policy framework and well-resourced staff (Odendaal, 2003).

ICTs are to function as tools for development and then skills development and improved access are key to achieving this. Underlying this technical development is the importance of social development—literacy training, public computer access and creating opportunities for participating in the ICT industry. Brisbane's efforts in this regard are based around partnerships; with State government in providing training in schools, with small-scale businesses in providing cheap hardware, and with small ICT businesses in implementing *ourbrisbane.com* portal for participation (Odendaal, 2003). The *ourbrisbane.com* project is promoted as an icon in itself; it is marketed aggressively as a key component of the Smart State and Smart City initiatives. It is seen as an underpinning to all of Brisbane long-term objectives and emerged as a project, in response to the need to make Brisbane a competitive city, nationally and regionally. Given the city and region's reliance on the service sector for growth, enhancing its function as a key service center through ICT development is seen as strategic and important for KBUD.

Brisbane shows the synergy that can come from public–private partnerships (private partners in *ourbrisbane.com*, in providing access for communities to inexpensive hardware), from networks with other state agencies such as State Education in providing various initiatives and internet training; and working with Federal and State government in establishing opportunities for one-stop service payment and registration online around life-events (Odendaal, 2003). This synergy is combined with the strong local economy and lifestyle options to attract more knowledge intensive industry and workers, which supports KBUD within the region.

Knowledge HUBS in Brisbane

A feature of globally competitive knowledge economies is that governments, universities and industry work together in these economies to create regional "knowledge hubs". Knowledge hubs have three major functions: to generate knowledge; to transfer and apply knowledge; and to transmit knowledge to others in the community through education and training. The Queensland Smart State and Brisbane Smart City strategies have augmented KBUD in and around Brisbane. Brisbane and its metropolitan area have emerging strengths in a number of dynamic new sectors and knowledge hubs that will help drive the regional capacity to develop into the future. ICT, biotechnology and biosciences more generally, aviation and aerospace are examples of strong development opportunities which have the potential to make Brisbane a global player in the world's fastest growing industries (Andrews, 2006).

The Brisbane central business district and surrounding suburbs are home to globally recognized knowledge hubs and clusters such as Herston (medical research) and Kelvin Grove (creative industries, health). The ICT sector is developing in Queensland University of Technology at Gardens Point, Milton and Fortitude Valley, with government representation in the iLab incubator (Toowong) and Information Industries Board (Milton). Substantial activity is also centered around the University of Queensland at St Lucia with a range of research facilities, including the Institute for Molecular Bioscience and a natural resources/environmental cluster nearby at Indooroopilly Longpocket. A similar concentration is located south of the city, with Griffith University at Nathan, the nearby Mt. Gravatt Research

Park and Brisbane Technology Park at Eight Mile Plains. Emerging clusters are apparent at the Sunshine Coast, based on the University of the Sunshine Coast and at the Gold Coast with the Griffith University campus and the proposed knowledge precinct. The Gold Coast is also home to a thriving ICT industry and enterprises associated with leisure and entertainment (Queensland Government, 2005b).

Elsewhere in the region, there are specialist centers of research and development at sites such as Pullenvale (minerals and energy), Coopers Plains (pathology, biosecurity) and Cooroy (timber). The ongoing development of University of Queensland campuses at Ipswich and Gatton will be a key factor in diversifying that area's economic activity, as well as increasing access to education and training in the Western Corridor. Urban redevelopment areas, particularly ecoscience and lifescience knowledge precincts such as Boggo Road/ PA hospital, provide the opportunity for mixed-use development, incorporating high value-added research, development and service industries and linkages to university research facilities. Such developments have the potential to encourage industry clusters, which can be located either in close proximity or more distant, but connected by high-speed broadband and equipped with other ICTs (Queensland Government, 2005b).

CONCLUSION AND FURTHER TRENDS

Strengthening the knowledge base of cities through ICT strategies requires a broad intellectual team with expertise in ICT, urban development and management, urban studies and planning, socio-economic development, models of intellectual capital and knowledge management. It also requires a nuanced geographical frame that allows understanding in diverse spatial forms of the knowledge city, where a large number of knowledge clusters (e.g., universities, R&D institutions, knowledge precincts) are particularly important in the promotion of the spill over effects found to be vital for long-term economic prosperity.

It is evident from the Smart State and Smart City strategy and vision that Queensland and particularly Brisbane have the required KBUD potential. In Queensland and Brisbane the State and Local governments have and are being developed strong urban ICT strategies to strengthen the knowledge base of the state and the city. Successfully implementation and continuum of these strategies would likely to transform Brisbane into a globally competitive knowledge city, and its economy into a knowledge economy.

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KEY TERMS

Information and Communication Technology: The convergence of information technology, telecommunications and data networking technologies into a single technology.

Knowledge Based Development: A powerful strategy for economic growth and the postindustrial development of cities and nations to participate in the knowledge economy.

Knowledge Based Urban Development: A knowledge-intensive urban planning and development approach to nourish the transformation and renewal of cities into knowledge cities.

Knowledge City: The culmination and synthesis and reintegration of the creative city and the science city where knowledge, arts and sciences become unified in a uniquely human 21st century urban ecology.

Knowledge Economy: An economy characterized by the recognition of knowledge as a source of competitiveness, the increasing importance of science, research, technology and innovation in knowledge creation, and the use of computers and Internet to generate, share, and apply knowledge.

Knowledge Hub: Essentially, a region with an ensemble of knowledge-intensive organizations located in both public and private sectors.

Local E-Government: Refers to information, services or transactions that local governments provide online to citizens using Internet and Web sites.

Supporting Self-Regulated Learning with ICT

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INTRODUCTION

Technology has been speeding up the pace of change in our lives, forcing us to quickly come to terms with new knowledge and new tools in both formal and informal learning contexts. In the past two decades, this phenomenon has increased interest in self-regulated learning (SRL), a crosscurricular competence which supports lifelong learning by helping people become independent learners and by favouring the transfer of learning strategies and problem solving methods to different learning situations. SRL is also seen as a way to avoid "inert knowledge" (Whitehead, 1967), that is, knowledge that students have acquired but are unable to apply.

Research has shown that students who lack SRL competence not only have poor academic results but also show behavioral problems and difficulties in expressing their thoughts and feelings and in understanding those of others (Sanz de Acedo Lizarraga, Ugarte, Cardelle-Elawar, Iriarte, & Sanz de Acedo Baquedano, 2003). Therefore, it is not surprising that developing students' self-regulatory competence, in addition to teaching them content knowledge, is increasingly considered a major goal of education and an important field of educational research.

In this chapter we investigate whether ICT tools can support the practice and development of SRL and, if so, under what conditions. More specifically, we discuss what features of such environments are likely to favour SRL.

BACKGROUND

We can define self regulated learning (SRL) as a learning process where students master their own learning by setting their own goals, by choosing and changing their learning strategies when necessary, by reflecting on their own learning and in particular by evaluating their progress and consequently adapting their strategies. Self-regulated learners are often intrinsically motivated (Young, 2005) and see learning as a proactive activity; in other words, they *deliberately control* rather than *passively endure* the learning process. They usually have a good degree of self-efficacy and are able to apply and adapt the acquired knowledge across different subjects. According to Zimmermann (1998), SRL "is not a mental ability, such as intelligence, or an academic skill, such as reading proficiency; rather, it is the self-directive process through which learners transform their mental abilities into academic skills." The research in this field investigates the pedagogical, behavioral, emotional, motivational, cognitive and metacognitive aspects involved when students control their own learning processes (Zimmermann, 2001).

We will base our discussion on a widely accepted model, derived from studies of sociocognitive orientation (Steffens, 2006; Zimmerman, 1998). According to this view, SRL entails an active and conscious control of one's learning in terms of cognition (including metacognition), motivation and behavior, at both individual and social level. This approach also points out that SRL consists of a cyclical repetition of three phases, each of which provides input to the following one: forethought or planning; performance (which includes execution and monitoring); and evaluation of the achievements in relation to learning objectives. Self-regulation is then brought about by controlling metacognition, motivation, and behavior throughout these three cyclical phases. By systematically proceeding in this way, the students begin to adapt knowledge and competence acquired in previous learning experiences to new learning situations, in order to reach their current learning objectives. This characterization of SRL points out that learners' previous knowledge plays an important role in the practice of SRL in that it provides a starting point that learners can use to tackle new problems. It also suggests that SRL is a competence that improves more rapidly as people progress in education. Some studies, however, suggest that SRL does not improve quickly or spontaneously (Boekaerts, 1997), but requires suitable teaching and practice. The literature reports improvement in learning when self-regulation is explicitly addressed in classroom instruction (Schunk & Zimmerman, 1998). It also underlines the importance of creating and structuring favourable learning environments which stimulate reflection and revision, provide meaningful feedback and help learners to feel responsible for their own activity and achievements (Dettori, Giannetti, & Persico, 2006).

ICT-BASED ENVIRONMENTS AND SRL

Is it possible to understand the potential support to SRL provided by technology-enhanced learning environments (TELE) by analysing their features and the way they are used? To what extent does such support depend on the features of the software tools and to what extent does it depend on the way they are configured and used?

Such questions were addressed by a group of researchers from nine countries within a European project called TELEPEERS (1), which focused on TELEs of various kinds, from offline self-instructional programs to online collaborative courses. To guide the analysis of the TELEs, the TELEPEERS partners identified a set of features that, according to the literature, are desirable when SRL practice and development are among the learning objectives. The standpoint of this project was that the analysis should focus not only on the software component but also on its mode of use, since these two aspects are so strictly intertwined that their effects are too difficult to separate. Based on the aforementioned features, TELEPEERS also produced and tested two questionnaires (2). The first is meant to be used by teachers and/or SRL experts for an a priori evaluation of the TELE's potential, while the second is addressed to the TELE's users and allows a posteriori assessment of the tool and its use.

Based on the project outcomes, we further elaborated the TELEPEERS set of features and came up with the checklist in Table 1. This list, in addition to items referring to the three cyclical phases of SRL control identified by Zimmermann (planning, execution, and monitoring, and self-assessment), also includes a section on general features of the TELE structure and interface.

For the sake of generality, the list contains aspects that can be relevant for some kind of TELEs, but not necessarily for all of them. In order to clarify the possible meaning of the selected features in different situations, we will comment on two very different cases of TELEs, that is, virtual collaborative environments to run online courses and programs for individual use.

SRL in Virtual Environments for Online Collaborative Learning

The relationship between SRL and online collaborative learning is rather complex, since the latter appears to both support and require the former (Dettori, Giannetti, & Persico, 2006).

The fact that online collaborative learning supports SRL is suggested by three considerations:

- Online learning allows greater freedom of choice than face-to-face instruction (Williams & Hellman, 2004) since students can decide, at the very least, where and when to study, and often how to organize their activity. According to Boekaerts (1999), the perception of choice encourages self-regulation.
- In online collaborative courses, discussion and comparison with peers play a key role. According to Bolhius (2003), social experiences in general (not only online) are an important source of SRL competence.
- The need to put in writing one's thoughts and reflections, according to Kanselaar, Erkens, Jaspers, and Tabachneck-Schijf (2001), encourages reflection and assumption of responsibility.

On the other hand, self-regulation appears necessary to help students take advantage of online courses. In particular:

- Commitment, feeling of responsibility, reflection and the ability to plan the learning activity are even more important in online experiences than in traditional ones, in fact, satisfactory achievements in online contexts heavily depend on these aspects. As a consequence, students who are not used to

Table 1. Aspects of TELEs which potentially support the practice of SRL

General features that support all the phases of SRL
Intuitiveness and homogeneity of the interface. Possibility to personalize the interface. Help functions about how to use the software. Tools to facilitate navigation in the environment. Functions that support interaction with peers, teachers, tutors, and virtual agents present in the environment.
Features that Support planning
Planning tools like calendars, activity plans, and so forth. Explicit indications of the prerequisites for the assigned tasks. Suitability of the organization and layout of the internal or external resources available to tackle a task. Functions that keep track of one's activity within the environment.
Features that support task execution and activity monitoring
Multimedia educational material in different formats. Possibility to chose between different learning paths within the environment. Possibility to chose between various difficulty levels for the proposed tasks. Formative feedback. Tools to exchange materials and collaborate with other students. Help functions about how to carry out the task.
Features that support SELF-ASSESSMENT
Availability of models of correct task execution. Possibility to compare one's own work with that of peers. Self-evaluation tools.

online learning might find that this change in learning style requires nontrivial adjustments.

- Online learning requires students to be able to use the technology necessary to participate in online courses. For those who are unfamiliar with computer use, even operations like text-based communication or environment navigation may be challenging (Arbaugh, 2004).
- Using freedom profitably requires some training. As Schraw (1998) points out, learners need to have some minimal knowledge to be able to make informed choices. Paradoxically, some guidance is necessary to allow learners to exercise control (Jones & Issroff, 2005).

This analysis suggests that online collaborative environments can provide good opportunities for students to practice, and therefore develop, self-regulation, hence becoming better learners. Of course, this is more likely to happen if the TELE is designed and organized with this objective in mind, and our list of desirable features can hopefully be of help, especially in environments where SRL support appears to be a crucial aspect to the success of the courses.

What aspects of self-regulation can we expect to be supported in online collaborative environments? CMC (computer mediated communication) platforms are empty containers, which provide collaborative tools and organizational features only; hence their influence on SRL would appear to be limited to social behavior. Support to motivation, meta-cognition and individual behaviour, however, is not lacking, rather it is indirectly provided, since well organized and ductile platforms allow course designers and teachers to work out configurations and activities that support SRL in these respects too. The virtual presence of peers and tutors often compensates for those aspects that CMC platforms do not support directly. It is important, therefore, that people involved in the production and delivery of online courses become aware of such potentialities and pay attention to them while designing and running the course.

An analysis of several CMC platforms in relation to the above SRL model led us to distil a number of potentially beneficial features specific to this particular kind of TELE (Dettori, Giannetti & Persico, 2005a, 2005b):

- An easy and intuitive interface can reduce cognitive overload and allow students to concentrate on learning rather than on the use of the environment;
- Features for controlling and personalizing the individual workspace, such as grouping of messages and threads, and organization of folders and forums, can facilitate cognitive planning and avoid confusion; they can also raise awareness of one's own thoughts, learning style and current educational needs;
- Features for personalizing content presentation, by hiding/removing/ordering content items, distinguishing between read and unread messages and texts, adding comments and annotations, may support motivation and positively influence task performance;
- Methodological help can facilitate learners' conscious use of metacognition and reflection;
- Features to exchange and jointly edit multimedia documents, by managing their versions, can have a positive influence on task execution and group work;
- Tools for different modes of communication (public and private, textual, audio, and video, synchronous and asynchronous) can foster the development of personal initiative and support different learning styles, therefore improving motivation, stimulating positive emotions, and encouraging social behavior;
- Tracking functions, such as the history function, showing who has read or modified any item on the platform, can support planning and facilitate performance;
- Automatic reminders of appropriate actions to undertake can assist planning and support task performance;
- Features and tools for self-assessment, as well as the use of peer-reviews and reciprocal teaching strategies can inform and encourage monitoring and self-evaluation.

The support to SRL provided by such features of CMC platforms can be exploited and further amplified by setting up *ad hoc* functions for activity planning, by proposing learning materials and task assignments that stimulate reflection and self-evaluation and by using scaffolding and fading techniques that help maintain a positive attitude and motivation. To this end, it is necessary that materials and activities are cognitively well structured and explicitly make use of the potentialities of the platform used. A configuration and course plan that does not make full use of the features offered by the platform risks falling short of its potential. This happens, for instance, if a platform allows the use of multimedia files but the configuration only proposes textual materials, or if the planning tools provided, like calendars, are hardly ever used by tutors to pace shared activity nor are they proposed to the students to assist the organization of individual work.

SRL in Individual Learning Environments

Environments for individual learning usually consist of programs or multimedia systems with well-defined educational aims, specific contents and a structure and learning strategy that somehow follow from them. The above features vary considerably from case to case, making it very difficult to characterise these environments from the point of view of SRL as precisely as we did for online collaborative environments. A few considerations derived from the analysis of the SRL potential of environments of this kind, however, can help us to better understand their potential and limits.

It is important to remember, first of all, that the analytical approach applies to environments, not to programs; hence it is necessary to consider how programs are used to learn. By environment, in this context, we mean the setting needed to use the software as well as the activities and the tasks that students are asked to carry out and the type of scaffolding provided. The software component of a TELE, therefore, provides only potential support to the practice of SRL, which must be suitably exploited by careful pedagogical planning. This can be provided by the teachers if the program is used in the context of formal education, or even by the students themselves in the case of learners engaged in self-instruction.

It should also be clear that this particular kind of analysis of TELEs does not provide an evaluation of the educational validity of the software tools, but rather a guide to fine level debate on the characteristics of the considered programs and on possible ways of using them to support SRL. This often leads to a better understanding of software tools and related environments, by calling attention to aspects that might otherwise go unnoticed, and hence indirectly favors an evaluation of the educational potential.

From our analysis of TELEs, it appears that guidance is necessary in order to exploit the environments' SRL-related features, which seems to contradict the very idea of self-regulated learning. It is not quite so. As pointed out earlier, self-regulation of learning is not so much the *freedom* to organize one's learning activity, but rather the *ability* to do it, and this competence requires time to develop, as well as gradually fading support.

Practically speaking, features that make individual learning environments very promising from the SRL point of view are:

- An easy and intuitive interface;
- Tools to control and personalize the individual workspace, for example by choosing the difficulty level or making the student aware of the structure of the content domain, in such a way that the individual can choose the individual's own paths compatibly with prerequisite requirements;
- Tools that allow the interface to be configured according to learning style and individual preferences, for example by hiding complex functions or bringing to the forefront those that are frequently used;
- Methodological help including advice on how to proceed and examples of proficient use of the system;
- Features that allow the learner to seek help from peers and teachers;
- Availability of learning resources based on various media, allowing the student to choose between different learning modalities;
- Tracking functions, showing what has been done, as well as how and when it has been done;
- Automatic reminders of appropriate actions that should be taken at different stages of the learning process;
- Features and tools for self-assessment, including tests providing accurate feedback.

CONCLUSION

Using the approach described in this chapter to analyse the support to SRL provided by TELEs can be useful to teachers, course designers and researchers. Teachers can use this method for an *a priori* evaluation to spot strengths and weaknesses of the environments they are planning to use, and hence devise suitable activities to support SRL in all its aspects. Instructional designers can use our checklist while planning and developing learning environments and educational software that support SRL. Researchers can enrich and test our checklist or adapt it to different kinds of tools.

In all cases, it is essential to be aware of the self-regulation maturity of students in order to shape *ad hoc* configurations and modes of use that fit the target population.

Despite the increasing attention paid to SRL by educational researchers in the last two decades, much of school education and most TELEs are primarily focused on cognition and disregard the positive impact exerted on learning by motivation and metacognition. Diffusing the practice of SRL in schools could greatly improve education. To this end, it is necessary to raise both teacher and student awareness of the importance of all aspects of SRL. SRL should be explicitly included in the institutional aims, along with the learning of content knowledge, especially in teacher training programs.

Without students' and teachers' commitment SRL is likely to occur in a marginal and casual way and mostly by students who had already developed this competence to some extent. The use of well-structured TELEs can partially simplify this task in that the potential support granted by the embedded software component can help teachers to plan relevant activities and provide a guide for students who engage in the practice of self-regulation.

NOTES

1. TELEPEERS: "Self-regulated Learning in Technology Enhanced Learning Environments at University Level: a Peer Review", Grant agreement 2003-4710-/001-001 EDU-ELEARN, http://www.lmi.ub.es/telepeers/
2. Both questionnaires, called TELE-SRL and TELESTUDENTS-SRL, can be downloaded from the Web site of TACONET (http://www.lmi.

ub.es/telepeers/), an international association of teachers, scholars and researchers interested in themes stemming from TELEPEERS.

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KEYWORDS

Meta-Cognition: "The awareness of one's own cognitive processes, often involving a conscious attempt to control them" (VandenBos, 2007). The term refers to the activity of reflecting about one's own cognition or, in other words, thinking about thinking. In particular, metacognition includes reflection about one's learning process and it is believed to have a critical role in successful learning. Metacognitive learning skills include planning the way to approach a learning task, monitoring understanding and assessing the progress towards the objectives. Learning to learn and self-regulated learning entail a wide range of metacognitive skills.

Motivation: A dynamic mental state associated with the desire and willingness to exert effort towards the achievement of a goal. A motivated person is one that strives to achieve his/her aim, be it short or long term. Being a mental state, motivation is a function of the person, but being a dynamic state, it is also a function of the situation. According to Atkinson & Feather (1966), a student's motivation to invest time and effort in learning depends on his or her expectations of success and on the perceived value of good achievement. Some authors, such as Kuhl (2000), see lack of motivation like a consequence, rather than a cause, of performance deficits that occur when people repeatedly face failure. This leads to the distinction between intrinsic and extrinsic motivation. The former is when people engage in an activity because they like it or they are deeply interested in it. The latter has to do with obtaining external rewards like praise, money or good grades, as well as avoiding punishment or damage. In general, intrinsic motivation leads to deep learning, while extrinsic motivation might entail rote or performance oriented-learning. However, the potential of extrinsic motivation should not be underestimated because intrinsic motivation is easily endangered by many external factors, such as for example the need for money.

Online Collaborative Learning: This term identifies learning processes based on computer-mediated interactions between members of a learning community. This is called a virtual community since its members do not meet face to face. The interactions mostly consist of synchronous or asynchronous message exchanges and usually take place within a Computer Mediated Communication (CMC) system. The theoretical framework of online collaborative learning is that of socioconstructivism (Vygotsky, 1962). The terms Online Collaborative Learning and Computer Supported Collaborative Learning (CSCL) are considered to be synonyms.

Self-Regulated Learning: This term became popular in the past decade to emphasize students' autonomy and responsibility in taking charge of their own learning. In brief, self-regulated learners are able to establish their own learning goals, identify suitable strategies and tactics to achieve them, evaluate the results of their own learning, keep up motivation and deal effectively with emotional aspects throughout the learning process.

Self-Regulation: The capability to guide one's behavior along a specific path to a directed aim or goal. It includes goal setting, self-monitoring, self-evaluation, and other metaskills. It is strictly intertwined with motivation, self-efficacy (the belief that one is able to achieve the aim) and the ability to cope with failure. Research in self-regulation flourished in the 1980's, while in the 1990's important contributions started to appear in several related sectors, such as educational, organisational, clinical, and health psychology. The importance of self-regulation and self-regulated learning is widely recognized in that these capabilities are regarded as the main reason why our ancestors survived while other species extinguished due to the changing environmental conditions. Today, the need for self-regulation is even more important due to the fast technological evolution of our society, which makes life-long learning and the ability to adapt very desirable qualities of the individual.

Technology Enhanced Learning Environments: The term refers to learning environments where ICT tools are used to support and facilitate learning. Technology, though, is not the focus of the learning process, nor is it all a student needs to learn. The learning environment is a scenario comprising learning objectives, tasks, learning material, tutors, teachers, other students and technology. In this scenario learners can play an active role in their own learning process.

Technology Enhanced Learning in Continuing Medical Education

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INTRODUCTION

The traditional training programs will be increasingly intended as the early stages of a learning process designed to last over time under the direct responsibility of the individual.

This is true particularly in cases where professional knowledge is prone to rapid obsolescence. Such is the case of the medical profession where, besides an initial university education and professional development based on direct experience, there is the need for a process of continuous education on scientific research results and best professional practice carried out by colleagues (Manning & DeBakey, 2001; Wyatt, 2000).

It is precisely due to this requirement that many educational institutions and agencies in Italy have set up specific continuing medical education (CME) programs.

In particular, given the steady diffusion in the use of information and communication technologies (ICT), also in the context of the health care system (Curran, Hoekman, Gulliver, Landells, & Hatcher, 2000), special attention is currently being paid to the use of technology enhanced learning (TEL) approaches as a further means of providing educational activities within the CME (Letterie, 2003; Slotte, Wangel, & Lonka, 2001; Wutoh, Boren, & Balas, 2004). TEL is referred to the use of ICT to maximize learning within an environment of sound course design that can offer students the options of time, place, and pace and emphasizes different learning styles (TEL Committee, 2004).

The Italian situation is moving in this very direction on the grounds of both national *ad hoc* experimentations and local initiatives of individual Local Health Units (LHUs) (*).

In order to provide an actual overall picture of how much the educational models centred on the use of ICT are currently utilized in CME, between 2005 and 2006 the Institute for Educational Technology (ITD) of the Italian National Research Council carried out specific research whose results will be illustrated and discussed here in this paper.

RESEARCH BACKGROUND

In January 2002 the national project of CME was set up in Italy. Extended to all professionals in the health care sector (not only doctors then), the project is inspired by the principle of training intended as a duty-right of every professional to enhance their knowledge, skills and competencies, and tailoring them to technological and scientific progress. Therefore, the value of training, bound by ethical codes, becomes a prerequisite to maintain professional practice.

The practical consequence of CME being mandatory and extending to all professional categories is that every health care worker must accrue at least 30 CME credits per year.

The credit is recognised as both the quality of the training activity and the time dedicated to it on the grounds of the specific professionalism. By way of example, for each doctor, one training day entirely given over to CME—according to the highest quality standards recognised by the CME National Commission—corresponds to about 8-10 credits. This implies that, to reach the required 30 credits, each medical doctor must commit the equivalent of about four working days per year.

From an organizational and operational perspective, for the LHUs, it would therefore be desirable that, besides the time spent for the "live" training activity, as little time as possible should be added for "logistics" relating to participation. Hence the training activity should:

- Be primarily based on training offers accessible on the premises, thereby minimising as much as possible any travelling from the workplace;

- Be planned so as not to take up an entire working day but divided into training segments (or modules) each lasting one or two hours.

For this reason, since 2002 the national programme of CME has included, on experimental basis, Distance Education (DE) among the various ways of providing health care workers with training courses. Almost from the outset, interest has been oriented towards DE based on the educational use of ICT (Ruiz, Mintzer, & Leipzig, 2006).

RESEARCH AIMS

The aims of the research has been to draw up a picture in Italy on the ways of using TEL in accredited educational activities for CME, highlighting both the main approaches adopted and the critical issues related to their introduction.

In other words, it was agreed to proceed with not so much a quantitative survey on the use of TEL in CME, as rather a qualitative analysis on the ways it is proposed and managed and on the outcomes of its introduction within the LHUs which have already gained experience in the educational use of ICT.

However, research has not been limited to analyzing the use of TEL in the "formal" context of CME, that is, those related to accreditation, but has also spread to the use of ICT in "informal" learning processes. Health care is regarded as particularly suitable for the adoption of both educational approaches (Trentin, 2005).

"Formal" training refers to approaches based on a precise training programme, with a start and an end, a direction managed by the training provider and a scaffolding for the trainees made up of tutors, teaching materials, the presence of experts/specialists, and so forth. All this is independent of the use of learning strategies, whether individual, assisted, collaborative or blended.

"Informal" learning refers instead to those processes that see the individuals meet their cognitive/professional needs independently (Coiera & Dowton, 2000), even via "networked" interaction within professional communities of practice aimed at enhancing the sharing of knowledge and best practices.

From an initial reconnaissance carried out in the wake of research work and based primarily on what was presented at national conferences, since 2002 there has been an increasing diffusion of TEL approaches (above all "formal") within health care training. However its diffusion is scattered like leopard spots which is typical though during the initial stages of any innovation process.

METHODOLOGY

Having defined the specific research objectives and the corresponding indicators for the data collections, a sample was then defined, that is, those LHUs were identified which had already acquired experience using TEL methods in CME.

Subsequently an online questionnaire was administered, developed according to the above-mentioned indicators and divided into four sections relating respectively:

1. To the general approaches followed by the LHUs in proposing and using TEL;
2. To the opinions of staff interviewed about TEL;
3. To the characteristics of TEL courses already realised or planned;
4. To the "informal" learning processes based on the sharing of knowledge and good practices within the different professional communities.

However, before administrating the questionnaire, steps were taken for its validation and so it was piloted by a subset (about 10%) of the entire sample identified (84 LHUs).

Having made the necessary modifications suggested during the validation stage, the questionnaire was then e-mailed to those responsible for training in the LHU sample. Two weeks later, the ITD personnel contacted (by phone) those who received the questionnaire to offer support in compiling it. At the end of this stage, 61 of the 84 LHUs sample had answered and given their own data and information.

RESULTS

From the survey it emerged that the overall judgement of the LHUs on the use of TEL in CME is fairly positive. Nevertheless, as those responsible for training point out, there is a general feeling that more time is needed before the use of these methods become part of the health care staff's routine.

GENERAL APPROACHES FOLLOWED BY THE LHUs IN PROPOSING AND USING TEL

The LHUs have been lead to use TEL approaches mainly to facilitate course attendance for staff distributed over the territory (74%) and to test the specific methodology in CME (70%) in order to both innovate the training activities and to complement/integrate classroom education. 31% of LHUs have then stated that they use TEL approaches to also, but not only, reduce training costs.

In the majority of cases (79%), besides the single LHU staff benefiting from the TEL courses, they are also made available for LHUs operating within the national health service, LHUs belonging to the divided Vast Areas (**) making up each Italian region, as well as for those individual professionals working within the public services. In particular, it is considered more suitable to organise a distance training system on a regional scale rather than on a local scale. For this reason, only 21% of TEL courses are designed exclusively for staff of a given LHU.

More than half of the training activities (58%) have drawn on themes related to the specialist areas of medicine (viral hepatitis, prevention and treatment of decubitus lesions, etc.); 16% to cross disciplinary areas (e.g., rules and regulations, English language, etc.); 15% to administrative areas (office productivity tools; budgeting principles, etc.).

TEL Delivery

With regard to TEL delivery (Figure 1), 74% of the sample opt for *co-sourcing,* thereby relying on both internal and external resources. *Out-sourcing* (entrusting exclusively to authorized external providers) has been used for courses by 21% of LHUs and a mere 5% preferred to rely on internal resources alone (*in-sourcing*).

It is estimated in the future that these percentages are unlikely to undergo significant variations given the persistent shortage of specialized internal staff in the planning and running of TEL activities, and the consequent, almost compulsory choice of using co-sourcing.

The Platforms

With regard to the platforms used to deliver TEL courses (Figure 2), 18% of LHUs said they possessed their own, 4% were in the process of acquiring one, whilst the remaining 78% opted to rent one.

The most used platforms include Docebo, Tecnema, Learnet, Weblearning Agatel, Claroline and recently special interest has been shown towards Moodle.

It is interesting to note how several cases (21%) have already considered using the platform not only to deliver e-content, but also as a place to initiate learning processes connoted by a high degree of interactivity

Figure 1. Means of TEL delivery

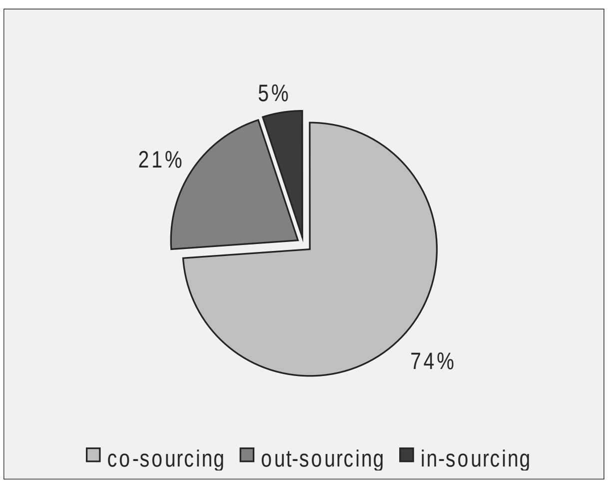
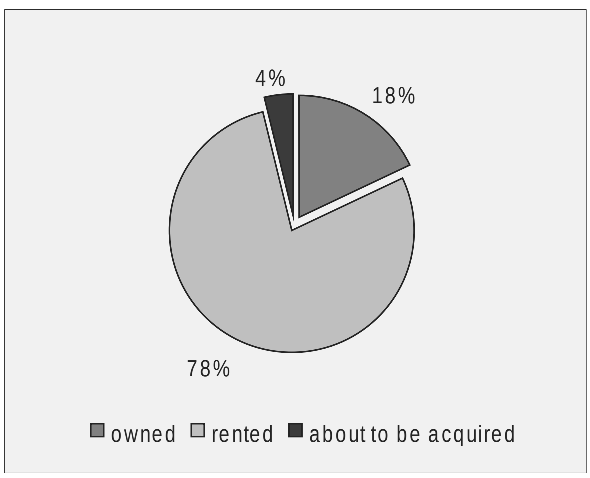


Figure 2. Platforms used to deliver TEL courses



among all the actors involved. This is due to a growing awareness of the possibilities offered by ICT in implementing forms of sharing and interpersonal dialogue, that are applicable not only in the sense of teacher-trainee relationship, but within trainee groups too. One is therefore turning more and more to the use of forum and e-groups as tools capable of managing actual networked learning groups with the aim of attaining higher quality levels of TEL activities.

A final note on the use of platforms concerns the need shown by many LHUs (63%) to be integrated with other companies' network services in order to foster continuity and complementarity between training activity and professional practice.

OPINIONS OF STAFF INTERVIEWED ABOUT TEL

Eighty-four percent of LHUs interviewed are convinced that TEL has the potential to bring about improvements in the quality of CME training. In order for this to actually occur though, certain key conditions have been highlighted:

- The option of using TEL approaches must be the result of a careful analysis of the educational needs of medical staff as well as the necessary background conditions regarding the content, environment, culture, technology, and so forth, for it to be actually applied to teaching;
- It is unadvisable to conduct a training activity relying entirely on the use of TEL since one cannot disregard the importance, if not the irreplaceability, of face-to-face interaction;
- The TEL system, besides e-content delivery, should guarantee the circulation of continuously updated knowledge by also levering on the activation of online professional communities and therefore sharing of experiences, opinions, and good practices inside and outside their company;
- Together with the content delivery, fast and decisive educational support should be guaranteed; hence the need for online tutoring as well as the need to train tutors (*e-tutors*);
- In order for TEL to be considered a valuable training practice on a par with the more traditional CME training methods, the certification criteria for both the content and delivery modalities should be defined more precisely, breaking away from the current concept of "any educational content transmitted via Web";
- Great care needs to be taken with regard to the "pressure" induced by producers of technologies and to the potential conflict of interests that may arise when educational activities are sponsored by pharmaceutical companies.

Eleven percent of the sample were rather sceptical regarding the possible improvements that TEL can contribute to the quality of CME. In their opinion, the most significant improvements are not related so much to the standard of quality of the training activity than to the containment of costs and to the facility of content delivery. From an educational perspective, they considered that the TEL approaches deprives the learner of the interpersonal relationship with both their colleagues and the content experts. Therefore TEL may only be suitable in a fairly limited number of cases, for training in technical content such as information technology, languages, administrative rules and so on.

These last considerations seem however to be conditioned by a rather stereotyped view of TEL, probably still due to a lack of awareness of the wide spectrum of possible educational approaches associated with it.

However, it is worth noting that these opinions are somewhat limited, since 95% of LHUs interviewed stated their intention in the immediate future of increasing the number of training activities delivered in TEL format. There are various reasons for this regarding:

- The extension of testing to a wider and heterogeneous range of both subjects and potential users so as to offer TEL activities to all categories of health care staff interested in CME;
- The implementation of more TEL courses in blended format;
- The testing of integration between "formal" and "informal" TEL, that is, between training based on prepackaged training products and new knowledge sharing/development. This is facilitated by the aggregation of internal staff in actual professional communities of practice based on networked interactions;
- The use of TEL to familiarize staff with new practices and new tools aimed at enhancing knowledge-sharing and company problem-solv-

ing processes, that is, improving company performance;

- A more precise analysis of the return on investment in applying TEL approaches, an analysis based chiefly on the evaluation of intangible returns. For example, these may include the capacity to provide for their own continuous education autonomously and, as already mentioned, the enhancement of peer-to-peer learning processes as well as knowledge-sharing and company problem-solving processes.

CHARACTERISTICS OF TEL COURSES ALREADY REALIZED OR PLANNED

The survey has reported that 41% of TEL activities (Figure 3) have been delivered using educational materials (e-content) with the assistance of tutors/trainers made available by the provider. 23% used a virtual asynchronous class to arrange distance tutored learning groups, while 21% used blended (online/onsite) solutions. 10% used teleconferencing to deliver distance lessons and discussion groups in real time, and lastly 5% relied on self-study (using structured educational materials without any kind of educational support).

In blended approaches, in particular, the distance stages favoured a virtual asynchronous class (62% of cases), followed by an assisted learning (23%) and lastly by self-study (15%). It is worth noting how in future prospective the LHUs reckon that there will be an ever-increasing trend towards the use of blended solutions.

The Availability of Qualified Tutors

As illustrated by the previous point, the LHUs clearly tend to adopt TEL approaches that include distance assistance for users. The logical consequence is that almost all (95%) distance/blended training activities delivered by the LHUs envisage the availability of tutors, with different functions due to the different TEL approach adopted (individual, assisted, collaborative, or blended).

In this regard, another interesting fact is that the LHUs have overall provided for a specific training of 88% of all tutors involved in the support of TEL activities.

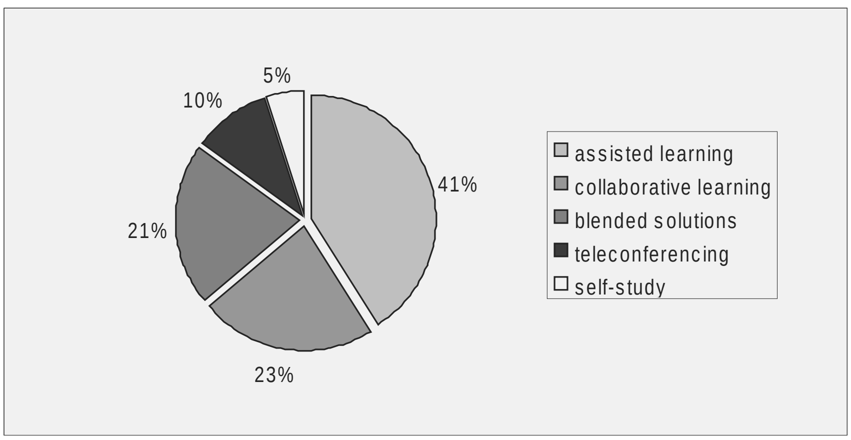
During the delivery stage, the tutors have mainly acted in assisting trainees in the use of e-content and TEL platform, in supervising exercises, in administrating assessment tests and in moderating online activities within virtual asynchronous and synchronous classes.

Hardly ever were tutors also required to provide content support and experts generally assumed this role involved in providing the course.

Learning Evaluation

Since TEL can exploit the specific characteristics of more technological media and more ways of supervising the training activity, in principle it has a wider range of

Figure 3.TEL approaches



possibilities for supervising the monitoring of distance activities and learning evaluation.

Nevertheless, what actually emerges from the survey—and is cause for concern—is that in almost all training activities (98%) the questionnaire has been used with priority in learning evaluation. The exclusive use of this questionnaire is indeed rather restrictive since the preset answers do not lend themselves very well to drawing an accurate picture of the target level of some types of knowledge and competence (Trentin, 1997).

To a much lesser degree, one resorts to practical tests (6%), to the development of project work (3%) and in just 2% of courses to evaluating the contents of networked interactions (reading messages produced by participants in their online learning group). The purpose is to discover exactly what and which particular skills they have developed in relation to the preset training objectives.

FORMAL AND INFORMAL LEARNING

One particularly interesting aspect emerging from the survey regards the evolutionary trend of TEL systems in health care. This is just what is predicted, in the medium-long term, by the LHUs with the most experience in the educational use of ICT.

In the vision of these LHUs, once through the first stage of cultural growth towards TEL approaches (on the part of both providers and users), it is then necessary to proceed towards integrating formal and informal learning formats. In other words, according to those interviewed, it is necessary to make sure that formal educational events (based on TEL approaches but not only) are not an end in themselves. Instead, they should become the springboard for self-run continuous education processes even by participating in online professional communities.

Therefore, what is proposed is a TEL strongly integrated with processes (spontaneous and/or induced) of knowledge management and sharing.

In confirmation of this trend, the survey showed that there are already online professional communities in 22% of LHUs. It is interesting to note how they initiated: in 60% of cases, they were promoted by the same LHUs and in 20% of cases; they aggregated spontaneously (generally according to the specific professional problems). In the remaining 20% of cases, the community incubator was a TEL course based on the learning group (Wiecha & Barrie, 2002) during which participants had a way of meeting and comparing their knowledge on specific professional themes, thereby providing the basis for their next participation in online professional collaboration.

DISCUSSION AND CONCLUSION

As indicated by the survey, the CME sector shows considerable interest in TEL methods. Unlike other companies' contexts, there is not only organizational and financial interest, but there are also questions involving the quality sphere of the educational processes.

This is a positive attitude not merely based on observing what occurred in view of the introduction of TEL but also on further untested potentials of the very approaches.

Consequently, the majority of LHUs interviewed have included a widening of the TEL offer in their future programmes in order to increasingly diffuse its use and to extend it to those professional profiles for which no specific courses have yet been developed to date.

The CME context, like many other educational contexts, entertains great expectations for the educational use of ICT. In view of this, there is however the awareness of a persisting wide range of critical issues that interposes between the innovators' enthusiasm and the actual extensive use of TEL approaches.

These critical issues range from the diverse cultural levels of the workers (doctors, paramedics, administration), to the poor computer literacy of some of these categories, to the lack of suitable skills in LHUs to run a training programme centred on TEL (from planning to delivery). Other critical issues are related to the difficulties often met in quantifying the number of ECM credits for attending TEL activities, the (poor) quality level of the courses, and the costs to readapt some training packages to a specific LHU needs. Furthermore, there is the difficulty in finding consultants and companies for the out-sourcing for the whole or some of the service, the difficulty in finding sponsor-free courses, and finally the inadequacy of evaluation systems.

All these critical issues can potentially prevent TEL from becoming an integral part of CME practices. However this is not a reason for despondency but should be a spur to raise a greater awareness of the pros and cons of adopting the method. Only in this way will it be possible to acquire the appropriate skills to carefully and consciously examine the offers coming more and more by the day from technology producers and commercial sponsors.

The research conducted by ITD has been the first real opportunity, on a national level, to highlight and analyse these problem areas so that the best solutions could be found to mitigate them gradually.

A further key element springing from the research is the developing awareness, especially of the LHUs with more experience in the educational use of ICT, of being able to effectively blend formal and informal learning processes via TEL. The most used strategy is to create, within a formal course, the best conditions to then develop informal learning processes. These may be based both on the autonomy of each individual to access knowledge sources and on their participation in online communities of practice where they can share knowledge and best professional practices.

To foster such processes, it is necessary to mix methodological approaches and technological environments according to the specific situation that can provide the opportunity to personalise learning and implement it following the specific organizational/company view.

The quality of TEL systems under these conditions will be increasingly measured in terms of its capacity to adapt to the requirements of the user, by offering a multitude of resources and services, including those distributed on a local level, and not necessarily developed for the specific TEL process.

Furthermore, the quality of TEL systems will also be evaluated in terms of the education of the users both in the individual use of TEL resources/services and in the capacity to become independent—once the "formal" learning process is over—in providing for their own personal continuous education in their professional content area.

NOTES

* The LHUs are public bodies with autonomy in technical, administrative management which organize health assistance in their own territory and provide it through public or accredited private organisations.

** A group of territorial districts, each falling under the competence of a specific LHU, belonging to a geographical subarea that divides an Italian region. For example, Tuscany, as regards the health service, is divided into 3 vast areas: North-West, Centre and South-East.

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KEY TERMS

Assisted Learning: A learning process based on both the individual study of educational materials and the guidance on the subject-matter by the tutor/trainer, who sometimes runs events such as networked workshops/seminars on course themes.

Blended Solution: Consists of an integration of classroom and distance learning activities, where individuals at a distance are supervised by using one (or more) online approaches (individual learning, assisted learning, collaborative learning).

CME (Continuing Medical Education): CME consists of educational activities that serve to maintain, develop, or increase the knowledge, skills, and professional performance and relationships a physician uses to provide services for patients, the public, or the profession. CME represents that body of knowledge and skills generally recognized and accepted by the profession as within the basic medical sciences, the discipline of clinical medicine, and the provision of health care to the public.

Collaborative Learning: A learning process based on both the individual study and the strong interaction among all the players in the process (trainees, tutors, experts), organized into actual networked learning groups.

Formal Training: Refers to approaches based on a precise training programme, with a start and an end, a direction managed by the training provider and a scaffolding for the trainees made up of tutors, teaching materials, the presence of experts/specialists, and so forth.

Individual Learning: A learning process based on the autonomous study of learning materials structured, tailored and developed explicitly to be used for self-study.

Informal Learning: Refers to those processes that see the individuals meet their cognitive/professional needs independently, even via "networked" interaction within professional communities of practice aimed at enhancing the sharing of knowledge and best practices.

TEL (Technology Enhanced Learning): Technology Enhanced Learning is referred to the use of ICT to maximize learning within an environment of sound course design that can offer students the options of time, place, and pace and emphasizes different learning styles.

Theories and Principles for E-Learning Practices with Instructional Design

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INTRODUCTION

E-learning has become an area of increasing interest for academics, consultants, and practitioners. Notwithstanding, it seems that in current experiences the instructional dimension is often overlooked. Many e-learning courses are content-oriented and the attention is often put on the technological dimension. We believe that a fruitful contribution in order to overcome the gap between technology and pedagogy and promote a more sensible instructional approach to e-learning, can be derived from *instructional design* (ID). ID is an ever growing field of research (Dijkstra, Seel, Schott, & Tennyson, 1997; Gagné & Briggs, 1990; Merrill, 2001; Reigeluth, 1989; Savery & Duffy, 1995; Wilson & Cole, 1991). Its results have a transversal value with respects to the specific delivery supports adopted in the learning environment. Whether we are dealing with online or face-to-face education, useful criteria from ID can be outlined for designing effective, efficient, and appealing learning experiences.

Therefore, with the aim of suggesting useful criteria and guidelines for e-learning design, this paper focuses on ID and examines some main approaches that currently characterise this field.

HISTORICAL AND THEORETICAL BACKGROUND

The field of ID emerged more than 40 years ago as psychologists and educators searched for effective means of planning and implementing instructional systems. One of the most important work for the growth of this field was Robert Gagné's *The Conditions-of Learning* (Gagné, 1965). According to the American psychologist, there are different levels of learning, each of which requires different types of instruction. He distinguished eight types of learning (from signal learning to problem solving) arranged in hierarchical order and proposed nine instructional events as conditions for learning. See Exhibit 1.

These events should provide the basis for designing instruction and selecting appropriate media.

ID from the very start, was configured as a field of research aimed at identifying criteria for the choice

Exhibit 1.

Instructional events	Cognitive Process
Gaining attention	Reception
Informing learners of the objective	Expectancy
Stimulating recall of prior learning	Retrieval
Presenting the stimulus	Selective Perception
Providing learning guidance	Semantic Encoding
Eliciting performance	Responding
Providing feedback	Reinforcement
Assessing performance	Retrieval
Enhancing retention and transfer	Generalization

of the most appropriate learning methods, taking into consideration the conditions-of-learning and the different learning methodologies. And yet this sector was often confused with other fields, thus generating ambiguity and misunderstanding. Recently, Reigeluth (1999) elaborated a deep study on ID with the purpose to clarify its specific field and focus on the epistemological nature of ID theories. Broadly speaking, an ID theory provides more or less general indications on how to facilitate learning and cognitive, emotional, social and physical development of people. But how should the term "theory" be interpreted, and what does an ID theory consist of, compared to other theoretical fields?

First of all an ID theory is design-oriented, that is, it focuses on how to achieve learning results. It therefore has a prescriptive nature, and does not involve the description of cause-effect relations between events, but indicates how to obtain specific results. An ID theory is not true or false, but involves a choice between possible preferable ways of intervening, and thus satisfies preferability criteria rather than that of validity.

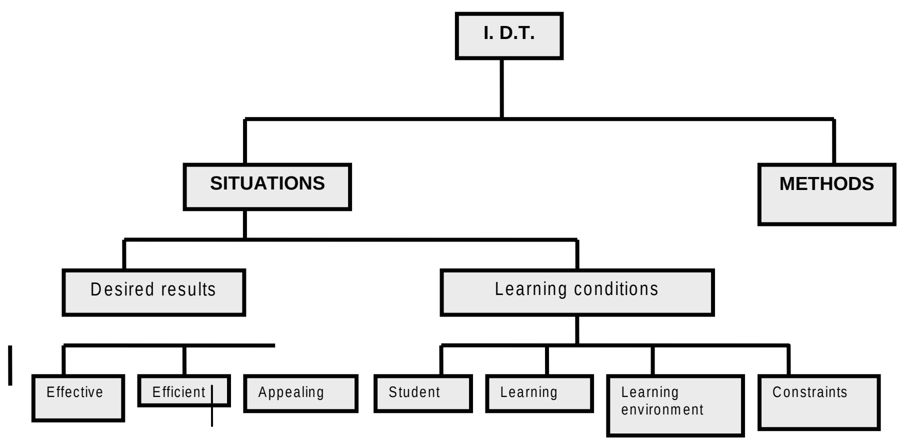
There is a tendency to identify ID with the area of learning theories. Obviously the relationship between these fields is very close since the learning theories have the fundamental role of explaining why an ID theory works or not. However, an ID theory involves the defining of the methods that facilitate learning and indicates the situations in which their use is preferable.

The methods have a situational nature and not a universal one, meaning that they work in certain situations and not in others. The situation affects the choice of methods and influences their applicability.

An ID theory therefore defines not only the methods, but also the situations, while identifying the aspects of the context that influences the choice of the method. In any learning situation, the most important aspects can be put into two macrocategories which are the learning conditions and the desired results. Among the first to be considered are: the nature of that which must be learnt (e.g., understanding concepts is different from developing abilities), the characteristics of the students (e.g., their previous knowledge, their learning strategies, their motivations), the characteristics of the learning environment (e.g., the activities could be carried out at home, or in a class of 20 students, or in small groups at workplaces, etc.), and the organizational and economic constraints. All these conditions can affect the choice of the most favorable methods for achieving the desired results. They must not be confused, however, with the *conditions-of-learning* of Gagné, even when the internal conditions coincide with the category, "student characteristics", while the external conditions are methods of learning and not conditions of learning. The desired results are the levels of effectiveness, efficiency (costs/time) and appeal (attraction for the student) with which one hopes to reach learning objectives.

The situation is therefore defined in a rather complex way and the intervening factors are multiple. This entails another characteristic of the ID methods, that is, they always possess a probabilistic nature. It means that an ID method does not guarantee that the application of an appropriate method in a certain situation will deterministically lead to the desired results, but

Figure 1. Elements of ID theory (Reigeluth, 1999)



does indicate a good degree of probability in a given situation, that the method will work.

Briefly, an ID theory identifies the adequate methods, so that, given certain learning conditions, learning results to be effective, efficient and appealing (Figure 1).

Currently there are two main approaches occurring in this field. The first is more traditional and is usually indicated as "instructivist". The second prefers alternative expressions like "learning communities" rather than "instruction" and leans towards constructivism.

In the second part of the chapter, we shall focus on these two different approaches, examining the ID principles developed in the traditional approach and the most recent evolutions of ID due to constructivism.

DO FIRST PRINCIPLES OF INSTRUCTION EXIST?

Merrill (2001), an advocate of the instructivist approach (Merrill, Drake, Lacy, Pratt, & ID2 Research Group, 1996), claims the right of ID to develop general principles in order to design instruction. According to Merrill, in comparing existing instructional models, it can be gathered that there are five instructional dimensions occurring in a transversal way: problems, activation, demonstration, application, and integration. What do such principles prescribe?

Problem. Learning is facilitated when the students concentrate on the solution of authentic problems. This principle is followed by resulting corollaries, that is, learning is facilitated: (1) when students are shown the task to achieve or the problem to resolve at the end of the course, rather than focusing on abstract learning objectives; (2) if the students are engaged in achieving a task or resolving a problem and not at the level of simple action or application of procedures; and (3) when the student solves more problems arranged in order of growing complexity for the gradual and progressive development of skills.

Activation. Learning is facilitated when pre-existing knowledge is activated as foundation for new knowledge. It is surprising, Merrill observes, how often we pass on immediately to presenting new information in very abstract forms, without first having prepared the ground for them to be understood. Activation implies much more than testing previous knowledge; it is rather the activation of those mental models that can be modified in order to allow students to integrate new knowledge with the existing one.

The best example for activation is that of the advanced organizers of Ausubel (1960, 1963).

Demonstration. Learning is facilitated when, what must be learned is demonstrated instead of just receiving information about it. Knowledge is often represented at a too general level rather than through examples. It would be more opportune instead, if examples and counterexamples were furnished for concepts, demonstrations held for procedures, and visualization done for processes and modelling of behaviour. Demonstrations entail a guide that helps the student to select the relevant information, the offer of the multiple representations of knowledge and also the comparison among multiple examples.

Application. Learning is facilitated when the student is given the opportunity to practise and apply new knowledge or abilities in the solution of a variety of problems. It is necessary obviously to provide adequate support (coaching) and feedback during the performance.

Integration. Learning is facilitated when students are encouraged to apply the new knowledge/abilities in real life, are given the opportunity to demonstrate their own new knowledge/ability, and are able to reflect, discuss and defend their new knowledge. Integration has positive effects on motivation. If the students have the opportunity to demonstrate their own progress, their motivation increases.

INSTRUCTIONAL DESIGN AND CONSTRUCTIVISM

During the last 20 years, studies in cognitive science and psycho-pedagogy have led to a meaningful change in the definition of learning. Three main research paths have been developed which, though similar, emphasize different aspects (Striano, 1999). These main perspectives consist of: (1) a constructivist approach which recovers the piagetian work, and interprets learning as an adaptive process in which the learner plays an active role of construction/de-construction of structure and knowledge strategies; (2) a historical-cultural approach referring to Vygotskij and interpreting learning as a mediated experience and as a socially shared and culturally constructed process; and (3) a contextual approach which emphasizes the ecological attitude of learning processes (Striano, 1999).

Therefore, new currents have emerged in the ID field as constructivist instructional design (Dick, 1991; Jonassen, 1994; Savery & Duffy, 1995; Wilson, 1996), which share the perspectives developed on the psycho-pedagogical level.

The instructional models which are oriented towards constructivism, put the emphasis on the concept of learning environment. This is defined as "*a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities*" (Wilson, 1996, p. 5). The idea is to set up around learners, multiple supports and resources available for their cognitive progress. This concept is derived from the Vygotskijan theory of zone of proximal development. The latter indicates a set of potentialities that the individual can develop, if adequately helped. In order to promote learning a varied environment consisting of learning resources, techniques, and interpersonal activities must be constructed around learners, so that each student can find the suitable atmosphere and the most appropriate **"**strongholds" to make progress.

Other authors provide further interpretations. According to Collins (1996), a learning environment should offer multiple representations of reality, avoid simplifications representing the natural complexity of the real world, focus attention on the building of knowledge and not of its transmission and reproduction, offer opportunities for learning based on real world situations rather than on predefined instructional units, nourish reflective practices, allow the building up of knowledge according to context and favor the cooperative construction of knowledge through social negotiation. Briefly, a constructivist learning environment is characterized by the following aspects:

- Focus on knowledge construction rather than knowledge transmission;
- Focus on context rather than abstraction thus presenting authentic tasks based on real cases;
- Multiple and complex perspectives on reality which stimulate metacognitive attitudes;
- Emphasis on social meaning negotiation and cooperative learning.

We now focus on two models arising from the Vygotskjian tradition, that is, the community of learners (Brown & Campione, 1990) and the Community of Practice (Lave & Wenger, 1991). What defines a learning community is the existence of a culture of learning in which each person is committed in a collective effort of meaning comprehension (Collins & Bielaczyc, 1999). The four specific factors that characterize such a culture are:

- The diversity of expertise among the community members
- The shared objective to contribute to the continuous growth of expertise and collective knowledge
- The emphasis on learning how to learn
- The setting-up of methods and tools for sharing what is learned.

A learning community can also be considered as a "social device" oriented towards favoring collaborative learning. It is characterised by members joining spontaneously and deep emotional relationships. A learning community cannot be designed in a strict sense, but is at most, "favored" or "cultivated". More analytically, according to Collins and Bielaczyc (1999), the issues to be addressed in order to promote a learning community can be analysed within eight dimensions:

1. **The scope of the community:** It is that of promoting a culture of learning, in which both the individuals and the community considered as a whole, learn how to learn. The members of the community share their efforts to reach a deeper understanding of what they are learning. The students learn to consider multiple perspectives to solve problems, and to use each other's knowledge and expertise as a resource to collaboratively solve problems.
2. **Learning activities:** The activities of a learning community aim at: (a) promoting individual development and collaborative construction of knowledge; (b) favoring the sharing of knowledge and abilities; and (c) making the process of learning visible and well structured.

A learning community is typically involved in learning activities, such as individual and group research, discussions, peer tutoring and learning, collaboration in artefacts production intended to make visible what students learn, and collaborative problem solving based on shared objectives. Brown and Campione (1996) suggest that learning community activities are distinguished by two aspects, that is, interdependent actions and interconnected objectives.

3. **The changing role of the teacher and transformation of the educational relationship:** In a learning community the teacher assumes the role of organiser and facilitator. The student becomes responsible for his/her own learning and that of the others.
4. **Centrality/peripheral and identity:** The member's identity is defined by the central or peripheral role he plays in the community and by the respect he receives from the other members of the community (Lave & Wenger, 1991). In a learning community the central roles are those that contribute more directly to collective activities and to community knowledge. There are, however, opportunities for all and the participants who assume peripheral roles are evaluated for their contributions. The centrality and peripheral aspects depend on the context. Individual identity is constructed through participation. Therefore the community identity emerges by working towards a common goal. It makes collective awareness grow, and favours the skipping of peripheral positions to favor centrality.
5. **Resources:** In a learning community the knowledge acquired and the learning processes enriched by external sources are shared between the members and become part of collective knowledge.
6. **Speech:** In learning communities language used to communicate ideas and practices emerge in the community through the interaction with the various sources of knowledge and the cobuilding and negotiation of meaning between the members. The learning communities construct a common language through which they express learning processes, plans, aims and assumptions. Speech assumes the function of a medium for the exchange of ideas; promoting moreover, the motivations of research and reflection, and arousing new questions and hypotheses that give rise to ulterior research. In this process the students help each other.
7. **Expertise:** In learning communities both individual and collective expertise are emphasized. Subjects that focus on principles and ideas that can generate wider and deeper comprehension of the themes themselves, are preferred. A growth in the community knowledge also occurs when the discussions on what the members have learned lead them to seek other knowledge to be shared within the community. Therefore there exists an inter-relationship between personal growth and that of the group.
8. **Products:** In a learning community the members collaborate to produce artefacts that can be used by the community to understand other themes or problems.

As regards communities of practice (CoP), they are defined by Lave and Wenger (1991) as groups of persons sharing an interest and regularly interacting to learn how to perform better. They are distinguished by three crucial features: identity that is defined on the strength of a shared interest, belonging to a community wherein the members help each other, and the sharing of practices. A CoP shares a program of resources, experiences, stories, tools, ways of problem resolutions, and in short, a program of practices.

INSTRUCTIONAL DESIGN AND E-LEARNING PRACTICE

We have just examined the two main current perspectives in ID field. How can they offer methodological insight for e-learning design?

As an example, let us consider the following case, that is, the methodological structure of a master on e-learning designing and managing delivered at the University of Florence since 2001. The master lasts one year (including a period of internship and one month reserved for the final dissertation) and provides blended learning, including f2f meetings and online activities supported by a virtual learning environment.

Briefly, the overall instructional model which characterises the master is based on the following principles inspired by both Merrill's Principles and learning community theory:

- Promoting problem based learning
- Favouring the activation of pre-existing knowledge
- Providing expert modelling through case studies and simulations
- Allowing students to apply knowledge and abilities in different contexts
- Facilitating knowledge integration through project based work
- Favouring the development of a community of practice
- Promoting students awareness on their own performances

How are these general principles concretely implemented? The master starts with a first phase of three months aiming at providing students with the conceptual handholds and expert examples concerning the various subject area. Each week is dedicated to a particular topic and is planned as described in Exhibit 2.

During the following three months, a completely online phase is delivered, which is oriented towards collaborative project work. The purpose of this phase is to enable participants to apply their own knowledge and skills in real life contexts (application and integration). At the same time, the emphasis is put on the formation of collaborative groups and the growth of a community of practice.

The team building process is favored by the sharing of a common interest and supported by the e-tutor. Students can choose among various scenarios referring to different contexts, that is, university, private company, public corporation, and so on. The groups therefore emerge from the interest in a particular scenario and operate within the selected scenario. Participants start to search and exchange information in order to create a common knowledge base and language. Next step is to define the objective to be accomplished and identify the necessary resources. The project work activity engages the students in a continuous problem solving process, asking them to develop different views on the same topic and to evaluate different possible solutions.

In addiction, two intensive face-to-face workshops are delivered with the aim of offering more opportunities for demonstration and application.

CONCLUSION

During the last 20 years, Instructional Design has gained its own autonomy as a specific field of research and has developed a theoretical reflection on its own epistemological statute. It is designated to elaborate instructional theories or models, able to indicate the adequate methods so that, given certain educational situations, learning can have greater probabilities of becoming effective, efficient and appealing. At the same time different approaches are emerging. One is more oriented towards the research of transversal fundamental principles applicable to a variety of contexts. The other, inspired by constructivism, is more intent on valorising the social and contextual dimension.

Even if the two approaches are different and in some way hardly reconcilable from a theoretical perspective, we believe that both the traditions provide methods and criteria that should be taken into consideration in e-learning design and practice. As noted, these criteria can be identified either in the Merrill's first principle of instruction or in the guidelines for cultivating learning communities.

In any case, professionals and practitioners in the e-learning field should not overlook the instructional dimension, while paying special attention to the research contribution from instructional design.

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Exhibit 2.

PROBLEM	**Monday**	**E-tutor** **ONLINE WORK** The e-tutor presents the subjects and the themes that will be examined and discussed during the week. He also introduces the subject matter experts (SME). At the same time, he provides documents and learning materials on the subject area, and focuses on the fundamental questions that will be addressed in face-to-face event.		
ACTIVATION	**Monday** **Tuesday** **Wednesday** **Thursday**		**Students** **ONLINE WORK** Students achieve their tasks autonomously or in small groups supported by a Web forum. They must identify problems and issues emerging from the provided learning materials and documents. Eventually they realize a concept map or a final report on	**SME** **ONLINE SUPPORT** During this period the SME may interact if needed with students giving support and hints on the subject area. He therefore intervenes in the Web forum collaborating with the e-tutor.
DEMONSTRATION	**Fryday (afternoon) and Suterday (morning)**	Before the face-to-face event, the e-tutor summarizes students reports and submits the final report to the SME so that he can arrange the face-to-face lecture on the emerged issues.		**FACE-TO-FACE WORK*** During the face-to-face event, the SME discusses the issues identified by the students giving feedback and adding new information and examples on the subject area.

continued on following page

Exhibit 2. continued

DEMONSTRATION	**Suterday (afternoon)**	**FACE-TO-FACE WORK *** The e-tutor gives ulterior information on the discussed themes, and organises possible in-depth examinations if needed.	**FACE-TO-FACE WORK*** Students will realize personal works taking into consideration the information and the suggestions provided by the SME and supported by the e-tutor . The personal works will be inserted into the student portfolio.
* Students who cannot be present to the face-to-face event, may participate and interact with the SME and other students through a videoconferencing system.			

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KEY TERMS

Constructivism: Epistemological theory according to which individuals construct knowledge through active experience. It emphasizes that knowledge is a social product, historically and culturally situated, and which is negotiated, constructed and learned by the members of a community.

E-Learning: A Neologism created at the start of the 2000s to indicate a set of methodologies aimed at using the ICTs in order to provide learners with learning resources and interactions free from temporal and spatial constraints. Three main solutions can be distinguished: content + support, wrap around, and integrated model. These three structures are respectively based on content, teacher's support for activities between peers and the Internet, and the collaborative learning group.

Instructional Design: Is the sector which has to do, on international levels, with the study of criteria and instructional models applicable to diverse contexts, in such a way that learning has a greater possibility of becoming effective, efficient, and appealing.

Learning Community: It is a notion that received a great attention in last years by educational scholars. According to Bielaczyc and Collins (1999) the four essential characteristics to define a learning community are: (1) diversity of expertise among its members, who are valued for their contributions and are given support to develop; (2) a shared objective of continually advancing collective knowledge and skills; (3) an emphasis on learning how to learn; and 4) mechanisms for sharing what is learned (p. 272).

Learning Environment: A definition currently accepted in literature is "*a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities*" (Wilson, 1996, p. 5).

Zone of Proximal Development (ZPD): The ZPD theory goes back to the work of social psychologist Vygotskij, according to which social interaction is critical to learning. He considers the learning process as continuously moving from an "actual development level" to a "potential development level". The movement between these two levels, where the ZPD lies, occurs through the interaction of an expert and a novice.

Towards a Framework for Evaluating ICT-Based Materials

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INTRODUCTION

Information and communication technologies (ICTs) present interesting challenges for educators and ICT designers, not the least of which is the evaluation of learning. Syverson and Slatin (1995) argue that software and hardware have evolved into a bewildering range of programs and peripherals while networks innovations add still another layer of complexity. As a result, teachers must not only continuously learn how to use these rapidly changing technologies, but they must also rethink their teaching practices, design new activities for teaching and learning, and try to evaluate the learning of students as they engage those activities.

What makes the evaluation of ICT-based learning more problematic is the issue of just what is being evaluated. For example, although there is an extensive and ever-growing literature about "learning objects" (LOs), the clarity of the term continues to be elusive (McGreal, 2004). The various approaches to defining LOs attempt to meet two common objectives: to reduce overall costs of digital resources and to obtain better learning resources (Wiley, 2003), but these two objectives often receive differing emphases. For example, Downes (2001) stresses efficiency while Duval, Hodgkins, Rehat, and Robson (2003) focus on effectiveness. Further, while some writers (Mortimer, 2002) claim that most LOs have clearly defined characteristics, there is ongoing disagreement about the nature of these components (Merrill, 2002).

Nevertheless, irrespective of how LOs are defined, there are "great expectations for [them to] transform teaching and learning practices" (Moore, 2003-2004, par. 2), and their raison d'être is their ability "to improve student learning" (Moral & Cernea, 2005, p. 3) by engaging students with the designed learning material, the subject content, and the delivery system. Hence, any discussion on criteria for evaluating ICT-based materials needs to acknowledge the complexity of the concept of student engagement (Clarke, 2004) and how it is operationalised in LOs to enhance learning outcomes.

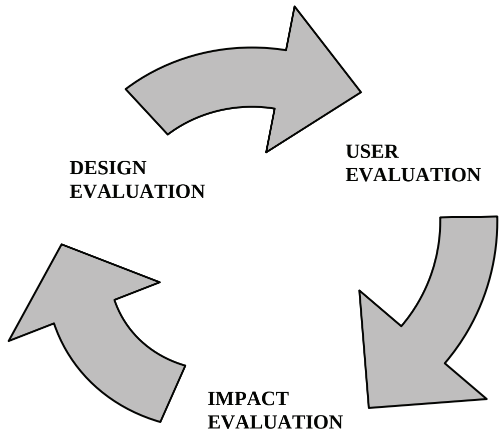
EVALUATING ICT-BASED MATERIAL

The evaluation of ICT-based materials requires the development of criteria for judging them, entities that are not readily available (Currier & Campbell, 2002). Haughey and Muirhead (n.d.) claim that attempts to evaluate such materials are "fraught with complexities not found in assessing other non-digital educational content" (p. 13) because such materials differ from more traditional learning materials in significant ways: They use a variety of media such as text, graphics, sound, video, and music; the content has to be disaggregated to a optimal size and both the content and structure have to be flexible enough to maximise reuse in a variety of contexts (pp. 13-15). Furthermore, the ICT infrastructure has to have sufficient capacity to run the materials.

It is not surprising then that most current evaluation processes (e.g., Carr, 2000; Griffin, 2003; The Le@rning Federation, 2002) concentrate on being sensitive to the overall goals that designers and developers have for such digital assets as well as the constraints upon designs imposed by the subject content and the infrastructure capacities. However, this "design and development" phase is only the beginning. Like most product development, there is a cycle which includes:

- The design and development phase of the LO
- The intended audiences' reaction and uptake of the LO
- The actual impact and outcomes facilitated by the LO

Figure 1. The beginnings of a framework for evaluating ICT-based materials



When these three phases of the product development cycle are considered, any framework that proposes to evaluate LOs will need to incorporate criteria for judging them at each phase. These evaluation foci are referred to here as:

- Design evaluation
- User evaluation
- Impact evaluation

These foci provide the beginnings of a framework for evaluating ICT-based materials as summarised in Figure 1.

Before dealing with each of these foci and the criteria associated with them, it is necessary to discuss the pedagogical principles underpinning the framework that guide the educational soundness of the design, use, and impact of ICT-based materials.

PEDAGOGICAL PRINCIPLES FACILITATING STUDENT ENGAGEMENT

A recent comprehensive list of criteria with a specific focus on how online curriculum materials may facilitate the engagement of students has been generated by The Le@rning Federation (TLF).[2] The criteria are designed to provide specifications for the educational soundness of online curriculum materials (TLF, 2002) where "educational soundness" is defined as "the capacity of online curriculum content to successfully promote student learning" (p. 4). The criteria "provide the broad framework for the design and development of ... online content" (Atkins & Jones, 2004, p. 2). The criteria, which have received international recognition (Haughey & Muirhead, n.d) and are metatagged to Australian school curricula, are underpinned by the four principles of learner focus, integrity, usability, and accessibility. These principles, all of which articulate with the notion of engagement, are defined and discussed in detail in TLF (2002) but are summarised below.

Learner Focus

This will be achieved by designing a LO that:

- Reflects the relevant learner profiles based on intended users (e.g., age and stages of schooling; socio-economic status) and enables learners to interact with, organise, represent, interpret, and manage the process of learning and the information flow (e.g., making choices and decisions, inquiring, investigating, and problem solving)
- Makes explicit and consolidates the process of learning (e.g., structuring informational content in order to scaffold student learning)
- Contextualises student learning (e.g., establishing connections with prior and likely future learning; supporting communication, activity, and collaborative action, both online and off-line)
- Maintains learner focus through the interaction between users and the learning content (e.g.,

content assemblage, generation, conversion, and publishing)

Integrity

This will be achieved by designing a LO that:

- Accurately represents the ways of knowing and conceptualising of the content domain
- Uses the language and symbols of the content domain and its ways of representation and supports students in developing and using them
- Presents controversial issues with balance and fairness and in accordance with mandated curriculum policies, where these apply
- Supports students' deepening of knowledge within the content domain
- Assists the learner with identifying and differentiating between different points of view and perspectives presented
- Incorporates content area advice supplied by expert representatives from relevant domains and practice areas.

Usability

This will be achieved by designing a LO in which:

- The purpose, process, and intended outcomes of the learning are explicit
- Learning and information design is intuitive (i.e., the user knows what to do and how to do it)
- The time and effort needed to use it is reasonable
- The media is exploited to maximise the opportunities for learners to achieve the learning outcomes
- Content is constructed in manageable and meaningful concept chunks to facilitate learning.

Accessibility

Online content will be accessible when it:

- Complies with accessibility standards for students with disabilities and for rural and remote communities
- Utilises the capacity of multimedia to support student acquisition of standard Australian English or standard New Zealand English
- Provides specific language support for students whose first language is not English
- Is appealing to and inclusive of students of all genders, socioeconomic groups, ages, races, and cultures

The application of these criteria to design, use, and impact evaluation is now discussed.

DESIGN EVALUATION

Based on these criteria, TLF has developed a detailed iterative process for evaluating LO prototypes to provide feedback into the design and development phase, which they call an "in school evaluation" (ISE). The ISE process is built around cognitive task analysis methodology (Hall, Gott, & Pokorny, 1995), which involves a very detailed and close scrutiny of each screen and is linked to individual students' learning profiles. The ISE is carried out with a sample representative of the intended audience, in this case, primary and secondary school students, and focuses on technical issues such as the aesthetics of the design, the interaction, the navigational processes, the links between screens, the challenging nature of the tasks, and the language difficulty and understanding of meaning. The ISE focuses on evaluating the design specifications and has the ultimate purpose of determining the potential of the proposed learning design to support the targeted users in achieving the learning objectives and outcomes.

USER EVALUATION

The evaluation of ICT-based learning materials often ends after the design and development stage when the LOs are put out to the market. However, the user uptake depends not only on the educational soundness of the LOs but also on the capacity of the end users to engage with them. Quantitative criteria such as number of teachers choosing to use the LO and the frequency of use are good indicators of user uptake. Further, how the LOs are being used will provide authentic feedback and also evaluate in a realistic manner some of the macro issues of equity and utility identified in the education soundness criteria. Such evaluation supplements the ISE feedback and adds to the appreciation of the full potential of the LO to be integrated into everyday classroom learning activities and to engage students.

LOs are instructional artefacts which can be integrated into classroom learning activities in a variety of ways. However, there is very little research to date investigating this aspect of ICT-based learning materials, although recently, there has been recognition of this hiatus with the beginnings of the exploration of the professional competencies that teachers use to engage with and develop innovate learning activities using ICT-based materials (Atkins & O'Conner, 2005; Muirhead & Haughey, 2005). "The outcomes of using learning objects rely not just on the intrinsic properties of the learning objects but on the teaching and learning processes adopted in the classroom" (Freebody, 2006, p. 21). How the teacher interprets and integrates the LOs into the teaching-learning situation needs to be evaluated.

IMPACT EVALUATION

Perhaps the ultimate test for the large investment in the development and deployment of ICT-based learning materials is the impact they have on learners—the quality of the learning outcomes. A number of evaluation criteria have been developed as indicators of the quality of learning outcomes (Nesbit, Belfer, & Leacock, n.d.; also see www.merlot.org). Typical of these are relatively simple tracking of such aspects as attention given to the buttons, menus, text, and types of user-object navigation. The approach used here, consistent with the complexity of the student engagement notion central to the effectiveness of LOs, is to go beyond that to evaluate the quality of the knowledge acquired by learners. To do this requires the melding of structural and design characteristics with qualitatively different conceptions of respective discipline knowledge and thinking.

There are a plethora of taxonomies that reflect the complexity of thinking (Anderson, 2001; Linn & Miller, 2005), but the structure of observed learning outcomes (SOLO) taxonomy (Biggs & Collis, 1982) offers a vehicle against which the students' structural and functional aspects of knowledge may be matched. Its superiority to other taxonomies as an indicator of student learning outcomes has been cogently argued by Hattie and Purdie (1998). It provides a means of evaluating the complexity of thinking facilitated by the LO by classifying it as either:

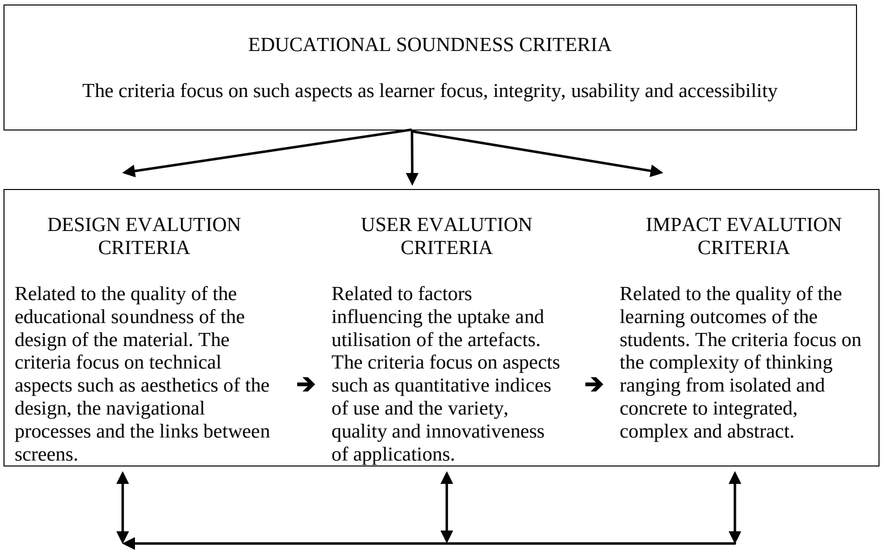
- **Prestructural:** Incompetence; nothing is known about the area of knowledge
- **Unistructural:** One relevant aspect is known but there is no relationship of facts or ideas
- **Multistructural:** Several relevant independent aspects are known but are not interrelated
- **Relational:** Several aspects of knowledge are integrated into a structure that has coherence and meaning
- **Extended abstract:** That coherent whole is generalised to a new domain/topic area to a higher level of abstraction

The levels are ordered in terms of characteristics such as from concrete to abstract, an increasing number of organising dimensions, increasing consistency and the use of organising or relating principles and can be considered as criteria for evaluating the quality of student learning outcomes. There are two general approaches to this. The first approach is to analyse existing outcomes. It has been used in poetry, history, mathematics, science, economics, chemistry, geography (Hattie & Purdie, 1998), and, more recently, in the evaluation of student-developed Web pages in English and history (Kimber, Pillay, & Richards, in press). Extending the work of Kimber et al. offers the exciting development of challenging students to identify a problem and to create a solution. Similar strategies are being explored by TLF (S. Atkins, Director of TLF Online Initiatives, personal communication, February 24, 2006) where "students" become "designers" (Murphy, Harvell, Sanders, & Epps, 1999). The range of content areas is testament to the robust applicability of the taxonomy. The second approach is to construct test items reflecting the levels.[1] This can be done using traditional test item construction procedures (Biggs, Holbrook, Ki, Lam, Li, Pong, & Stimpson, 1989) or, in the context of an LO, "repurposing" the LO to assess learning (Atkins & O'Connor, 2005).

PROPOSING AN INTEGRATED FRAMEWORK

By combining the design evaluation, user evaluation, and impact evaluation criteria, it is possible to provide an inclusive framework for the comprehensive evaluation of ICT-based materials. By integrating the TLF criteria with an evaluation of the level of knowledge

Figure 1. A framework for evaluating ICT-based learning materials



demanded by the LO, and by evaluating the degree and quality of uptake, it is possible to produce a set of evaluation criteria that is multidimensionally comprehensive and addresses the complexity of student engagement. This framework for evaluating ICT-based materials is summarised in Figure 2. The total evaluation process is iterative in that relevant information from later stages can be recycled back into earlier stages as required.

CONCLUSION

In beginning to develop a framework for the evaluation of ICT-based materials, it was necessary to draw on the product development cycle that led to the identification of design, user, and impact evaluation criteria. Relevant design and impact evaluation criteria based on the ISE work of TLF (2002) and with the SOLO taxonomy, respectively, were put forward as quality examples of ways to evaluate the design and development of online learning materials and their manifestation as learning outcomes. Linking these and elements are the user evaluation criteria which address how the teacher interprets and integrates the LOs into the teaching–learning situation and it has been posited that this process is the key to the quality of the learning outcomes in students. There is significant evidence relating to the reluctance of teachers to take on new technologies (Russell, Lucas, & McRobbie, 2003; Syverson & Slatin, 1995). For there to be any chance of successfully integrating ICT-based materials into mainstream classroom learning, there is a significant need for the professional development of teachers in this area at both the preservice and in-service levels.

NOTES

1. This chapter is associated with a joint University of Melbourne, Queensland University of Technology and The Le@rning Federation research project funded by the Australian Research Council grant #LP0454996. The authors are indebted to Stuart Tait, Manager, Market Information and Research, and Susan Atkins, Director, Online Initiatives, both at The Le@rning Federation, for comments on earlier drafts of this chapter.
2. The Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) established The Le@rning Federation in 2001 to produce online curriculum materials and supportive infrastructure to ensure that teachers and students in Australia and New Zealand can use

these materials to widen and enhance learning experiences. For more information, please see http://www.thelearningfederation.edu.au

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KEY TERMS

Evaluation: The development and implementation of a plan to assess a program in a systematic way through quantitative and qualitative measures, and the use of that information to improve the program. This involves collecting information about a prototype resource that will help in its development and ensure it works effectively and also collecting information at the end of the developmental phase to estimate the success and quality of the resulting resource.

Learning Objects: Bodies of digital material specifically designed to engage and motivate student learning. Each learning object has a learning objective, content, and activities that support the objective and assessment activities that reflect that expectation; they usually take less than 15 minutes to complete; the content is metatagged to some set of standards; and the object can exist on its own and be provided to the learner in a just-in-time and as-needed fashion.

ENDNOTE

[1] Only four levels are measured as the Prestructural is not considered.

T

Towards a New Model for Knowledge Construction and Evolution

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INTRODUCTION

The 20th century has marked the transformation of the philosophical definition of knowledge into a new and different one. The new idea of knowledge mostly depends on the experiences and theories from human and social sciences like psychology, pedagogy, anthropology, sociology, and so forth. But many contributions to its specification are also due to biology, neurophysiology, telecommunication, cybernetics, and other scientific disciplines. In other words knowledge is today a complex matter and its analysis and definition depends on the observation fields one can use for its analysis.

Since the origins of philosophy Plato and Aristotle marked the difference between the different ways of constructing knowledge by proposing two alternative perspectives, that is, idealism and empiricism. The reasons for the philosophers' assumptions can be synthesized in two radically different viewpoints for the analysis of human-reality interaction: the former assigned to human mind the right of observing reality, interpreting and thinking about it with the use of well founded mental categories to arrive to the production and development of new knowledge, the latter assumed that reality is true by itself independently from human beings so that it has to be analyzed, measured and read, otherwise stated mankind has to interact with reality to know it.

During the centuries the ideas of idealism and empiricism cyclically alternated with more or less success until the 19th and 20th centuries when human sciences developed new ideas for the interpretation of knowledge phenomena. Today further elements coming from communication sciences and organization theory are adding to the aforementioned ones and make more complex and articulated the panorama of ideas on knowledge construction and development.

In what follows two different viewpoints for knowledge analysis will be proposed: the former concerning individuals, the latter organizations.

KNOWLEDGE AND INDIVIDUALS

J. Piaget (1971, 1973) and D. P. Ausubel (1990) are among the first scientists stating the importance of subjects' mental actions in cognitive processes. They assign a great role to the subject-reality interaction for the explanation of knowledge development and evolution; for this reason they are also considered cognitivists and precursors of constructivism (they are usually classified as the first interactive constructivists). They, on another hand, assign a little or no role to social and cultural interactions in knowledge construction and evolution. The ideas from J. Piaget and D. P. Ausubel have been verified, integrated and, sometimes, contradicted from further scientist but have retained all their importance for the role they assigned to individuals in knowledge management and development.

On a different basis moved D. H. Jonassen (1994), who founded the project of learning environments on the following statements: (a) knowledge construction is based on individual and social influences, (b) meaningful contexts support problem solving skills (which have to be derived from real situations), (c) cooperation between student and teacher and among peers is at the basis of learning processes. He also suggested the idea of cognitive apprenticeship as a teaching-learning strategy strongly based on the experience and the reflection on it.

Further studies introduced the concepts of multiple intelligence (Gardner, 1993), learning styles (Mc Lellan, 1996) and cognitive flexibility (Spiro & Jehng, 1990), to consider the complexity of the cognitive phenomenon into individuals.

The importance of context and social effects on individuals' knowledge construction and development has been stated in many other studies, often under the influence of L. Vygotskij and A. N. Leont'ev hypotheses (Varisco, 2002). The first assigns a leading role to language and social interactions and hypothesizes the presence of ZSP (zones of proximal development) to mark the differences existing among the differently skilled subjects in a community. The latter is better known for his activity theory, where subjects work on objects in order to obtain a desired outcome; to do this people employ tools, which may be external (i.e., a material instrument) or internal (plans, etc.). Y. Engeström (1987) proposes a scheme of activity different from that by Leont'ev because it contains three interacting entities: the individual, the object, and the community.

The most recent theory on the influence of social phenomena on human knowledge and learning is the E. Wenger's (1998) social learning theory. This theory has at its basis the following principles: (a) individuals are social beings and are the focus of the learning action; (b) knowledge is a specific aspect of competence; (c) knowledge is the expression of the participation; (d) meaning is the product of learning. If these ideas are mostly concerned with the effects of learning actions on individuals it has to be noted that E. Wenger looks at communities as autonomous realities and, for him, communities of practice coincide with learning communities.

CORPORATE AND ORGANIZATION KNOWLEDGE

While starting from Wenger's research on communities of practice recent studies analyze knowledge construction in those communities for the importance they have in corporate and organizations. In other words a theory of knowledge construction and development in communities has been developed, autonomously from the hypotheses on knowledge construction in individuals reported in the above paragraph.

Among the starting points for these studies there are Wenger's (2004) basic elements marking a community of practice: (a) shared identity domain, where membership implies a commitment to the domain, and therefore a shared competence that distinguishes members from other people; (b) community, because in pursuing their interest in the domain, members engage in joint activities and discussions, help each other, and share information; that is, they build relationships enabling them to learn from each other; (c) practice, because members of a community of practice are practitioners; they develop a shared repertoire of resources: experiences, stories, tools, ways of addressing recurring problems (in short a shared practice).

With respect to studies on individuals' knowledge development, new hypotheses were now developed to explain knowledge features and structure within communities and organizations. I. Nonaka and N. Konno (1999), for example, based their ideas on the definition of two different kinds of knowledge: (a) tacit knowledge, which is deeply-rooted in actions and experiences of community's members and can be only difficultly codified, transmitted and shared; i.e. it is the individuals' "know how" marking the skills of the community, (b) explicit knowledge, which is the community's knowledge and can be easily formalized, represented, transmitted, and shared.

Activity theory intervenes on the difficult problem of learning and, particularly, on tacit knowledge by suggesting that organizational learning process includes preliminary stages of goal and problem formation (Engeström, 1997).

As regards learning organizations, that is, organizations continuously developing new knowledge, I. Nonaka and H. Takeuchi (1995), developed a model for knowledge construction and evolution strongly based on the tacit and explicit knowledge transformations. This model is made by four phases (which initials give the name SECI to it): (1) socialization, it is the informal process letting tacit knowledge be shared (often in nonverbal way). It has features very similar to the modeling phase of apprenticeship and to the on-the-job-training used in many organizational contexts, (2) externalization, it transforms tacit knowledge in explicit concepts and is the crucial phase of knowledge construction. Formal language, metaphors, and analogies play an important role in helping people making explicit their know how, (3) combination, it inserts the newly built concepts into organization's knowledge and connects them to previous knowledge, so increasing the knowledge of the community and of the organization, (4) internalization, it closes the cycle by making internal the explicit knowledge and transforms it into know how for the organization.

THE ROLE OF IT AND ICT ON KNOWLEDGE CONSTRUCTION AND EVOLUTION

As regards the influence of IT and ICT on individual teaching-learning processes it has to be remembered here the contributions from R. Taylor (1980) and L.

Galliani (Galliani, Costa, Amplatz, & Varisco, 1999). The former proposed three metaphors for computer use in education: tutor, tool, and tutee; the latter extended these metaphors, while considering the great deal of software tools developed in last decades. At the end of such an integration tutor appellation describes the experiences people can make under behaviorist and cognitivist influence with the help of special programs, like CAI (computer assisted instruction), CAE (computer assisted education) and CAL (computer assisted learning) tools, or with the help of artificial intelligence software like ICAI (intelligent computer assisted instruction) and ITS (intelligent tutoring systems). Tool metaphor includes special software for analyzing large amount of data and browsing specific contexts (usually provided with authoring, co-authoring functions). Tutee metaphor mainly includes programs for the creation of special developmental environments, such as microworlds made by Papert with LOGO.

Together with computer metaphors, metacognitive ideas must be remembered. Strictly speaking they suggest that computer use stimulates functions' development more than learning topics so that meta-cognitive attitudes and learning are better developed in students systematically working at the computer (Cornoldi & Caponi, 1991).

Furthermore it cannot be discarded the application of activity theory to information systems (B. Nardi & O'Day, 1999); while supporting the study of HCI (human computer interaction) activity theory claims for the study of artifacts with respect to mental representations of reality. Following B. Nardi ideas, activity theory can be seen as a powerful and clarifying descriptive tool rather than a predictive theory (a metaphor for explaining how consciousness is located in everyday practice is: "you are what you do"); it is based in fact on a strong notion of mediation because all human experience is shaped by the tools and sign systems that people use.

At last the influence of ICT and especially of the Internet on knowledge construction and development must be recalled. As regards individuals H. Rheingold (1994) introduced the definition of virtual communities to describe the subjects using the Net for interpersonal communication and knowledge construction, D. de Kerckhove (2000) introduced connective intelligence to describe the set of strategies and cognitive skills developed from individuals contextually to ICT use, P. Lévy (1996) stated that collective intelligences well characterize the situation emerging from the increase in the individuals' communication speed in the Net and from the great amount of information freely available in it.

On another hand, the impact of ICT on learning environments is mostly due to the role it can play in educational contexts: (1) repository for information and documents of every kind (CMS – content management system), (2) system for the management of learning objects (LMS – learning management system), (3) virtual environment letting individuals interact and build communities of learners (CSCLS – computer supported collaborative learning system).

In communities and especially corporate and organizations, knowledge management has seen a great application and use of ICT for the collection, organization, sharing and analysis of knowledge. The tools adopted as instruments for the application of knowledge management principles are devoted to knowledge discovery, and knowledge audit (usually based on knowledge mapping) together with the planning and carrying out of knowledge networks.

In this direction G. Trentin (2004) hypothesizes for networks, and especially for the Internet, the role of technical infrastructure letting communities build a shared memory (i.e., shared knowledge basis supporting professional CoPs).

At last A. Cartelli (2007) suggests that implementation of practices by means of ICT can:

- Create communities where never seen before,
- Help people in bringing to consciousness their tacit knowledge and share it with the members of the community
- Deeply influence knowledge management strategies (by passing from the management of community data to the management of community processes).

As a result ICT will make easier the transfer of information and knowledge among the members of a community and will help the development of learning activities in corporate, organizations and in more traditional contexts like school and continuous education.

TOWARDS NEW MODELS FOR KNOWLEDGE DESCRIPTION

The elements reported until now clearly confirm how complex and articulated can be the description of knowledge phenomena. In what follows two different viewpoints will be adopted.

The former one will aim at representing the knowledge perspective (i.e., the different kinds of knowledge will be listed and the correlations among themselves will be proposed, with no reference to subjects, communities or any possible source of information). Figure 1 drafts the author's hypothesis for a tripartition of the possible kinds of knowledge: individual, community, and society (science) (Cartelli, 2006).

By individual knowledge is meant here the knowledge that each subject constructs and develops while interacting with reality. Community knowledge is the knowledge of a community in its entirety, or by using Wenger's words, the knowledge letting people identify in that community and the most part of signs, symbols and languages adopted from the members of the community itself. Society knowledge (mostly scientific knowledge) is the knowledge which is well codified and approved from individuals and communities (it could be better described from scientific paradigms).

The reasons for this scheme are reported:

a. Subjects develop knowledge by interacting with the environment they are immersed in and share such knowledge with people in the communities they belong to and in the society (there is no proportion among the single parts and the whole individual knowledge in the scheme). Individual knowledge will neither identify with community knowledge (except very exceptional situations like the one emerging in a little community, e.g. a family), nor will identify with society knowledge (the better example in this field is the presence of misconceptions and mental schemes in scientific disciplines, marking the differences between individuals' representation of real phenomena and their scientific explanation).

b. Each community will have peculiar and special features, including knowledge, and different communities will differ one another for one or more aspects. People belonging to more than one community will have their personal knowledge which partially will overlap that of the communities they belong to; on another hand there will be aspects of community knowledge which will be proper of that community so that no identification with other communities will usually happen. Furthermore community knowledge will never identify with society knowledge because of the presence of the tacit knowledge of community's members with respect to the presence of the only formal knowledge in the society (i.e., language, signs and codices adopted from community's members will very rarely be accepted and validated from society).

Figure 1. Tri-partition of the contributions in knowledge construction

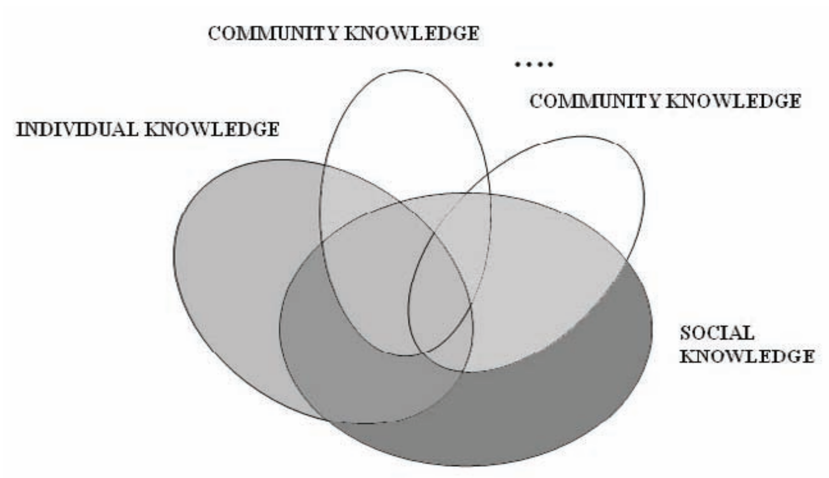
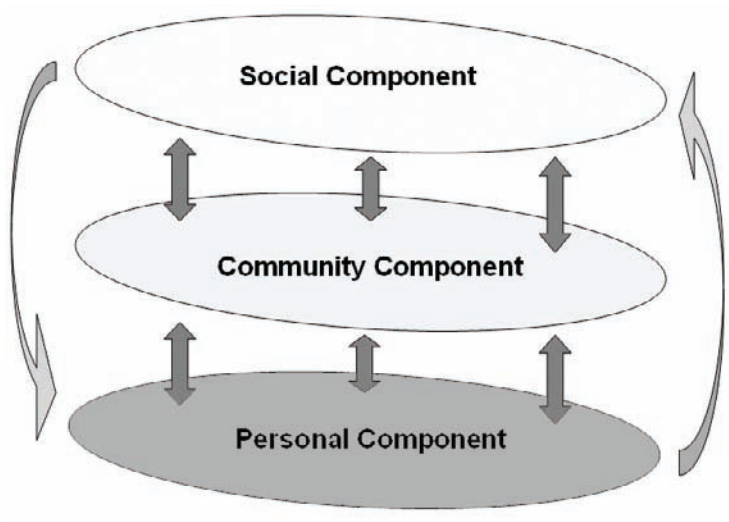


Figure 2. Interactions among the different components of individuals' knowledge



c. At last social knowledge will never completely identify or include individuals' knowledge and communities' knowledge, because of its features: data and information coming from subjects and communities can spread into a society, but the combination of the new elements with preexisting ones can only result from a process of mediation and validation. Any change must be recognized and accepted to have an official character and to become a property for the society (it must have the seal of acceptance).

The second viewpoint to be discussed here is the individual knowledge and its structure as a result of the abstract considerations reported above on knowledge structure.

From the scheme in Figure 1 it can be deduced that all the components described until now for knowledge can be present in a subject; personal, community and society knowledge all together appear in fact in the oval representing individual knowledge and overlap one another. Furthermore the same figure gives only a static description of the different elements in individual knowledge: when considering activity theory, social constructivism and all the theories reported above the static representation in Figure 1 appear inconsistent and a more dynamic view of the interaction among the various elements is needed.

The corresponding schema for what the author hypothesizes for knowledge interactions in a subject is reported in Figure 2.

It emerges from the earlier description of a complex schema for knowledge phenomena, both when looking in abstract at knowledge structure and articulation and when the influences among the different components of knowledge in a subject are analyzed.

CONCLUSION AND FUTURE TRENDS

The discussion reported on knowledge construction and evolution has interest by itself for the discussion still alive in the scientific community on knowledge features, due to the different perspectives in its analysis it opens. Furthermore, as regards individuals, it proposes a multilevel structure for knowledge description; otherwise stated subjects build their knowledge through the elements coming from three different channels: personal, community and society. The knowledge components all together contribute in the creation of the individual's knowledge.

Furthermore the same remarks suggest a change in the well-consolidated tradition of personal human learning. During last centuries, in fact, there has been the exaltation of personal reading for knowledge acquisition and development with respect to other ways of learning. Today collaborative learning strategies supported by the ICT give a great impulse to communities and to the development of common strategies and instruments for knowledge construction.

Coming back to teaching strategies we can conclude that new strategies are needed in education to let people develop a flexible and adaptive multilevel knowledge structure.

As an example the recent situation of ICT literacy studies and researches will be discussed here.

The reason for those studies can be easily found in the interest recently manifested from single scientists and public institutions for youth and its IT skills. Very shortly the debate concentrates today on the following topics: What means ICT skills? What are the ICT skills people need to be the citizens of knowledge society? Is the Net-generation automatically ICT skilled due to its immersion in today society? What must do schools inherently to ICT skills to help young people in developing the right ICT skills?

To answer all or part of the above questions a research project titled “Internet and School: Access Problems, Equal Policies and Information Management”, directed from professor A. Calvani in the University of Florence, Italy and funded from the Italian Ministry for Research and University, recently started. Within that project the local unit of Cassino, Italy coordinated from the author was charged of the analysis of the cognitive dimension of the Internet use (i.e., the access to information, its critical use and the construction of new knowledge).

The more relevant points emerged until now from the analysis of national and international literature and from the first surveys can be summarized as follows:

- ICT literacy skills do not identify with ECDL (European Computer Driving Licence) skills,
- Group dynamics in young people play a relevant role in the development of the ICT skills concerned with the acquisition and sharing of information,
- The Net-generation has high competence in receiving, storing, and transmitting information but has no deep understanding of the meaning of the operations and of the structure of information.

The above statements give only a provisional sketch of the results expected from the research group, which is still working on the development of a digital competence assessment questionnaire to be developed in a few months. Once ready it could be used in the schools to help teachers in the planning of suitable teaching strategies.

It is perhaps too early to say if the multilevel knowledge structure described earlier will play a relevant role or not in the final version of the questionnaire.

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KEY TERMS

Cognitivism: Looks at human beings like a black box where the input of information produces some output. It has a positivist and reductionist approach to the analysis of knowledge phenomena and is persuaded that psychological events can be fully explained by experiments, measurements and the application of the scientific method.

Communities of Practice: Introduced the first time by J. Lave and E. Wenger in their book on legitimate peripheral participation to explain the dynamics of communities' evolution when new people or less skilled people accessed to them. More recently they have been associated with knowledge management and organizational development.

Information Literacy: Has not been defined in a unique way. The more accredited definition states that information literacy is a set of competencies that an informed citizen of an information society ought to possess to participate intelligently and actively in that society

Intelligent Tutoring System (ITS): Any computer system providing direct customized instruction or feedback to students while using artificial intelligence strategies. It is made of three modules: student, tutor and expert. The first implements students features like knowledge and behavior (including misconceptions and mental schemes). The second adapts teaching strategies to the various contexts and to the students (i.e., uses the feedback from evaluation surveys to plan recovery actions for the students). The third contains a description of the knowledge or behaviors of the expert.

Multimedia Literacy: Extends the definition of literacy, i.e., read and writing at a level adequate for written matter, to the numerous media today in use.

Social Constructivism: Assigns a leading role to individuals' activity in the learning process, unlike previous educational theories mostly based on the passive and receptive role of the learner. It also recognizes the great importance of the symbol systems, such as language, logic, and mathematical systems, which are inherited by the learner as a member of a particular culture.

Social Network Services: Focus on the building of online social networks (i.e., communities of people sharing interests and activities) or let people explore the interests and activities of others. They are mostly based on web technologies due to the wide communication channels they make available: chat, messaging, e-mail, videoconferencing, voice chat, file sharing, blogging, and so forth.

The Transport-Level Requirements of the Internet-Based Streaming

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INTRODUCTION

Internet streaming media changed the Web from a static medium into a multimedia platform, which supports audio and video content delivery. Today, streaming media turns into the standard way of global media broadcasting and distribution. The low costs, worldwide accessibility, and technical simplicity of this telecommunication way make media streams very attractive for content providers.

Streaming works by cutting the compressed media content into packets that are sent to the receiver. Packets are reassembled and decompressed on the receiver side into a format that can be played by the user. To achieve smooth playback, packets are buffered on the receiver side. However, in case of network congestion, the stream of packets slows down and the player application runs out of data, which results in poor playback quality.

This article presents the comparison of different transport level congestion control schemes, including variants of the TCP (Postel, 1981). The protocol mechanisms, implemented in various protocols are hard to investigate in a uniform manner (Hosszú, 2005); therefore, the simulator SimCast (Simulator for multicast) is developed for traffic analysis of the unicast (one-to-one communication) and multicast (one-to-many communication) streams. In this article, the TCP and other transport protocol mechanisms will be compared using the *SimCast* simulator (Orosz & Tegze, 2001). The simulated results are presented through examples.

Due to spreading of traffic lacking end-to-end congestion control, congestion collapse may arise on the Internet (Floyd & Fall, 1999). This form of congestion collapse is caused by congested links that are sending packets to be dropped only later in the network. The essential factor behind this form of congestion collapse is the absence of end-to-end feedback. On the one hand, an *unresponsive flow* fails to reduce its offered load at a router in response to an increased packet drop rate, and on the other hand, a *disproportionate-bandwidth flow* uses considerably more bandwidth than other flows in time of congestion. In order to achieve accurate multicast traffic simulation—because it is not so TCP-friendly yet—the effects of the flow control of the TCP protocol should be determined. However, there are many different kinds of TCP and other unicast transport protocol implementations with various flow control mechanisms, which make this investigation rather difficult (He, Vicat-Blanc Primet, & Welzl, 2005).

Until now, a lot of comparisons have been done. For example, Wang et al. reviewed the TCP-friendly congestion control schemes on the Internet (Wang, Long, Cheng, & Zhang, 2001). They differentiated two groups of the TCP-friendly congestion control algorithms as follows: (1) *end-to-end* and (2) *hop-by-hop* congestion control mechanisms. The end-to-end mechanisms are grouped into (a) additive increase multiplicative decrease (AIMD)-based schemes with the window- and rate-adaptation schemes, (b) modeling-based schemes, including equation based congestion control schemes and the so called model-based congestion schemes, and (c) a combination of AIMD-based and modeling-based mechanism. Wang's classification is mostly used in our discussion, too.

Yu (2001) proposes another important approach about the survey on TCP-friendly congestion control protocols for media streaming applications, in which several TCP-friendly congestion control protocols were discussed via a comparison of many important issues that determine the performance and *fairness* of a protocol.

It is an important advantage of the simulator *SimCast* that the latest TCP congestion control mechanisms are also implemented. In this way, the cooperation among different TCP protocol entities or various other transport level protocols can be examined (Shalunov, Dunn, Gu, Low, Rhee, Senger, Wydrowski, & Xu 2005).

In this article, various TCP congestion control mechanisms as well as congestion control mechanisms for media streams are reviewed. Then a novel simulator for transport protocols is described and the various simulation results summarized. Lastly, conclusions are drawn and future work is identified.

OVERVIEW OF THE TCP CONGESTION CONTROL

The Basic Control Mechanisms

The framework of the TCP congestion control is the use of a *sliding window*. Its main concept is that the sender can only send a limited number of unacknowledged segments to the receiver (Jacobson, 1988). The number of segments to be sent without receiving acknowledgment is determined by the *congestion window* (*Cwnd*). The *Cwnd* is given in bytes, which is the total length of the segments that belong to the congestion window (Floyd, 2001).

The basis of TCP congestion control is based on *additive increase multiplicative decrease*, halving the *Cwnd* for every window containing a packet loss and increasing the *Cwnd* by roughly one segment size per *round trip time* (RTT) otherwise. The *retransmit timers* are of fundamental importance in highly congested systems, which have exponential backoff of the retransmit timer when a retransmitted packet itself is dropped.

The *slow-start* mechanism is for initial probing available bandwidth, instead of initially sending it at a high rate that might not be supported by the network (Stevens, 1997). At the beginning of the *slow-start* state, the *Cwnd* equals one segment size. During *slow-start*, the *Cwnd* is increased with a squared function in time. *ACK-clocking* is the mechanism that uses the arrival of acknowledgments at the sender to clock out the transmission of new data.

Congestion Avoidance

The TCP sender could enter this state from the state *slow start*, if the *Cwnd* reaches the value of the *target window* (*Twnd*). In state *congestion avoidance*, the increase of the *Cwnd* in response to a received ACK is:

$$\Delta Cwnd = \frac{B^2}{Cwnd}, \tag{1}$$

where *B* is the size of one segment in bytes. In the case of timeout, the TCP goes to the *slow start* state.

Fast Retransmit: Fast Recovery

The method uses *repeated ACK*s to detect packet loss. After receiving three *repeated ACK*s, the sender retransmits the packet determined by the *SeqNum* (sequence number) of the ACK immediately and halves the *Cwnd*. After this, the sender enters state *fast recovery*. At this point, it increases the *Cwnd* with three segments, then it increases with one segment in the case of arrival of additional repeated ACKs. Using this method, a lot of unnecessary retransmissions can be avoided; it is effective in the case of sequential errors. Applying this method, better network utilization and throughput can be reached, since the receiver does not need to wait for the *retransmission timeout*. The sender leaves *fast retransmit* when it receives a useful ACK or when a timeout occurs.

Selective Acknowledging (SACK)

This method is efficient in the case of multiple packet losses (Mathis, Mahdavi, Floyd, & Romanow, 1996). The receiver reports the segments that were received to the sender. In such a way, the sender retransmits the absent segments only.

CONGESTION CONTROL OF MEDIA STREAMS

TCP-friendly rate control (TFRC) is proposed for equation-based congestion control that explicitly adjusts the sending rate as a function of the measured rate of loss events (Handley, Floyd, Padhye, &

Widmer, 2003). The TFRC is a receiver-based congestion control mechanism, with calculation of the loss event rate performed in the data receiver rather than in the data sender. This is appropriate for an application where the sender is a large server handling many concurrent connections. Therefore, this is suitable as a building block for multicast congestion control. The TFRC is not a complete protocol; it is a congestion control mechanism only. It could be implemented in a transport protocol like *Real-time Transport Protocol* (Schulzrinne, Casner, Frederick, & Jacobson, 1996) or in an application incorporating end-to-end congestion control at the application level.

TFRC uses the following throughput equation directly to determine the allowed sending rate as a function of the loss event rate and the RTT. This equation is a simplified version of the throughput equation for the *Reno* TCP (Padhye, Firoiu, Towsley, & Kurose, 1998).

$$T = \frac{s}{R \cdot \sqrt{\frac{2bp}{3}} + t_{RTO}\left(3\sqrt{\frac{3bp}{8}}\right)p\left(1+32p^2\right)}, \quad (2)$$

where T is the transmit rate in bytes/second, s is the packet size in bytes, R is the RTT in seconds, p is the loss event rate, t_{RTO} is the TCP retransmission timeout value in seconds, and b is the number of packets acknowledged by a single TCP ACK. For simplicity, $t_{RTO} = 4R$. $b = 1$ in most cases, however, if the competing TCP implementations use "*delayed ACKs*," $b = 2$ is a more appropriate value.

During operation, the TFRC receiver measures the loss event rate and feeds this information back to the data sender. Then, the sender uses timestamp fields in feedback messages to measure the RTT and feeds these measured values into the throughput Equation (2) to get the acceptable transmit rate. The sender then adjusts its transmit rate to match the calculated rate.

The TFRC is reasonably fair when competing for bandwidth with TCP flows but has a much lower variation of throughput over time compared with TCP, making it more suitable for applications such as streaming media where a relatively smooth sending rate is of importance. The flow is "reasonably fair" if its sending rate is generally within a factor of two of the sending rate of a TCP flow under comparable conditions (Handley et al., 2003).

The drawback of smoother throughput than TCP while competing fairly for bandwidth is that TFRC responds slower to changes in available bandwidth than TCP. Thus, TFRC should only be used when the application has a requirement for smooth throughput, in particular, avoiding TCP's halving of the sending rate in response to a single packet drop.

SIMULATION RESULTS

Implemented Protocol Entities

A virtual testbed called *SimCast* was developed to analyze the effects of the important transport protocol TCP on multicast traffic. Standardized TCP and TFRC protocol entities are implemented in *SimCast*, described below. In the protocol entity *TRFC*, the rate-based AIMD-driven congestion control mechanism is implemented, which uses Equation (2).

The SimCast Simulator

The network topology used during our simulations is shown in Figure 1. The network endpoints are connected by two LAN links and a wan link. In TCP simulations, we sent large data files from host *H02* to *H01* using simple file transfer application protocols on top of TCP. We implemented TFRC as a transport level protocol, and we operated simple streaming applications over it between the same hosts as in the case of TCP simulations with the same data transfer direction. We used *drop tail* gateways, and we generated congestion events using explicit packet drops on the network links. Our TFRC implementation applies the *WALI algorithm* (Floyd, Handley, Padhye, & Widmer, 2000) for *loss event* calculation.

Simulation: TFRC-Periodic Losses

In the first simulation, we present the characteristics of TFRC in the case of idealized periodic packet losses on the network link. The loss rate is set to 2% in time interval [50..130 sec], and it is set to 5% in any other case.

Figure 1. Simulation topology

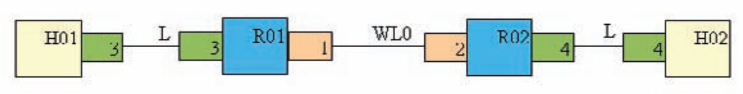


Figure 2. TFRC average loss interval and the latest loss interval (s0) with idealized perfectly periodic losses

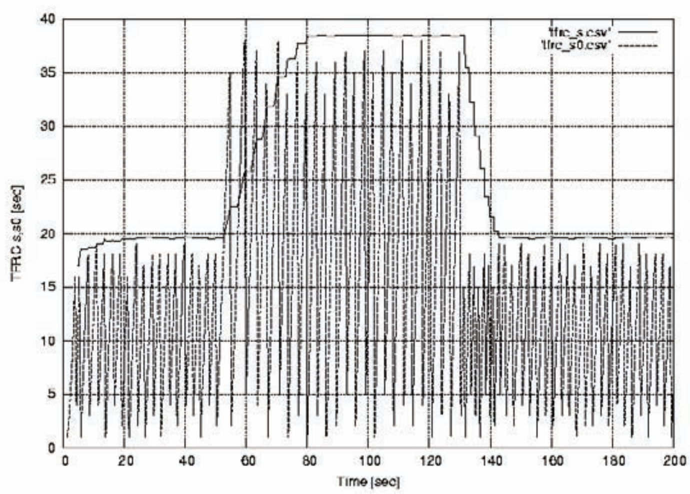
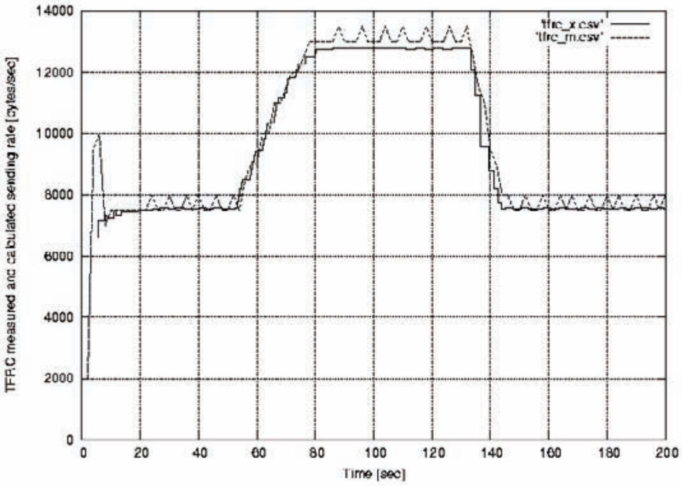


Figure 2 shows the last loss interval using dashed line, which is the number of received packets since the last detected loss event at the receiver side.

The average loss interval, which is calculated using the *WALI algorithm*, is shown by solid the line. This algorithm averages the most recent samples of loss intervals using a weight function which calculates the weight of elements in the recent half of the history with the factor of 1, and with linearly descending factors as we advance toward the least recent elements in the second half of the history. As can be seen in Figure 2, the average loss interval follows the last loss interval smoothly. The calculated loss event rate is the reciprocal of this value. As this value is calculated at the receiver and the sender uses it in the sending rate calculation, the value should be included in feedback messages. It is apparent that the algorithm eliminates aliasing effects of incoming and outgoing loss events in the history. This simulation scenario is similar to the one that was carried out by the *ns2* team (Floyd et al., 2000). Comparing the results of the two simulations, it can be stated that the TFRC entity of *SimCast* produces very similar results to the *ns2* protocol entity.

The calculated and measured sending rates of the TFRC sender are shown in Figure 3. The simulator keeps track of outgoing and incoming packets and logs the summarized bandwidth. The period of bandwidth logging is set to 5 seconds. At the start of the simulation, TFRC probes the available bandwidth using a slow start mechanism because, in this time period, there is no valid packet history at the receiver side to calculate the sending rate. This slow start behavior is similar to TCP's *slow start*, but TFRC cannot use the ACK clocking mechanism to control the sending rate. Therefore, to avoid flooding the network, TFRC does not send more than twice as much data to the network that was sent in the last RTT. This limitation keeps the initial sending rate of TFRC as twice the available bandwidth during a slow start. The peak of the measured sending rate at the start of the simulation is caused by the slow start. After the first loss indication TFRC exits the *slow start* state. At this time, TFRC has no valid history of

Figure 3. TFRC's calculated and measured sending rate



loss events, so TFRC fills the history with initial data calculated from the measured sending rate.

Concurrent Simulation of TCP and TFRC Flows

This simulation demonstrates the concurrent execution of TCP-friendly flows. The goal of this kind of simulation is the qualification of TCP and TFRC flows fairness. By this, we mean that the sending rate of TFRC flow should be approximately the same as that of a TCP flow under the same conditions of round-trip time and packet loss rate.

The simulated flows are of type TCP *Tahoe* and TFRC. Figure 4 depicts the bandwidth share of the two protocol entities. The granularity of the bandwidth logger was set to 2 seconds for both flows. The upper darker lane denotes the bandwidth utilization of the *Tahoe* entity; the lower lighter area represents the bandwidth share of TFRC. We set the packet drop rate of the WAN link in the topology to 7%. Figure 4 shows that the long-term bandwidth share of two flows are relatively fair; however, the sending rate of TCP varies largely.

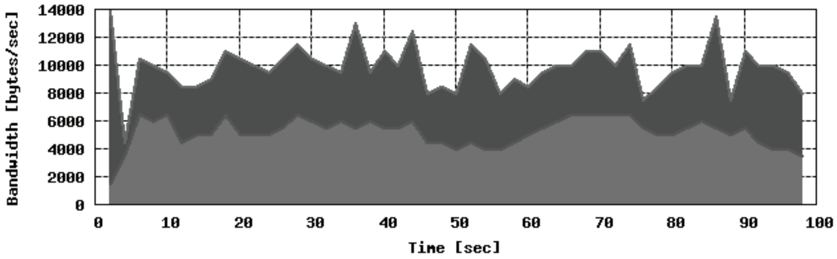
Using the output data resulted by this kind of simulation, one can qualify the *smoothness, responsiveness*, and *aggressiveness* properties of concurrently running flows. Here we define smoothness intuitively as the degree of sending rate variations over time for a particular flow in a stationary environment. Responsiveness describes how fast the deceleration of the sending rate is when there is a step increase of network congestion and aggressiveness is the acceleration rate of protocol sending rate to improve network utilization when there is a step increase in the available bandwidth. Our earlier simulations pointed that generating smoother traffic measured by time samples improves fairness measured by population samples.

For more precise numerical qualification of the flows' fairness, it would be more appropriate to simulate several flows simultaneously, since running more flows concurrently increases the level of statistical multiplexing, which makes it possible to carry out more realistic simulation of TCP-friendly flows. Such simulations can be performed using *SimCast*; however, this simulation result is carried out for the visual demonstration of protocols bandwidth share only.

CONCLUSION AND FUTURE DEVELOPMENTS

Our primary goal is the development of a qualifying system, which can be used to classify various transport

Figure 4. Bandwidth utilization of concurrently running TCP Tahoe and TFRC flows



level protocols from a TCP-friendliness point of view. The qualifying process should provide the maximum amount of information about the investigated protocols running the minimum amount of simulation. Our simulations confirmed that TFRC is more suitable for multimedia applications than TCP implementations because of its smoother sending rate, and it is also justified that TFRC can be stated as TCP-friendly because the examined protocols long-term throughput and other relevant parameters do not differ significantly from each other. Therefore, the protocols implemented in *SimCast* can be used as the basis of such a qualifying system. The simulation results were compared with the results from *ns2* (Floyd et al., 2000), and they seem to be qualitatively identical.

Using the developed protocol qualifying system, one can determine some fairness related properties of TCP-friendly flows such as smoothness, responsiveness, and aggressiveness. In addition, several other measures of protocol fairness can also be qualified. To refine the results of the analyses, future development should take more parameters into the qualifying process, such as the queuing dynamics and throughput covariance of competing protocol entities.

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KEY TERMS

Congestion Control: A mechanism that can be built into a protocol. Its main goal is to help the data transmission to avoid the overflow in the buffers of the routers inside the network.

Data Stream Applications: The class of large receiver set, low bandwidth real-time data applications.

Goodput: The bandwidth of the useful packets at the receiver side, which is also called the effective receiving rate.

IP-multicast: Network-level multicast technology, which uses the special class-D IP-address range. It requires multicast routing protocols in the network routers. Its other nameis network-level multicast (NLM).

Port Handling: From the network, the processes running in a computer can be addressed with an integer number between 0...65535 called port. Some port numbers are mapped steadily to important applications. They are called well-known port numbers. For example, the Web server typically uses the port number 80.

Reliability: The improved quality of data transmission. Different types of reliability exist, including data accuracy or real-time delivery.

Round Trip Time (RTT): The time period that is necessary for sending a packet from the sender to the receiver and for sending it from the receiver to the sender.

TCP (Transmission Control Protocol): Widely used for bulk data transmission. It is suitable for file transfer, but not for streaming media transmission.

Transport Layer: This is an abstraction; the protocol belonging to the transport layer is responsible for the port handling and sometimes the improved reliability of the transmission.

TTL (Time-To-Live): A field in the IP packet header. Its value is the allowed hop-count, the number of routers, which can forward the packet before delivery or dropping out.

Understanding RFID (Radio Frequency Identification)

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INTRODUCTION

RFID, also known as radio frequency identification, is a form of Auto ID (automatic identification). Auto ID is defined as "the identification of an object with minimal human interaction" (Puckett, 1998). Auto ID has been in existence for some time; in fact, the bar code, the most ubiquitous form of Auto ID, celebrated its 30th year in commercial use in 2004 (Albright, 2004). Barcodes identify items through the encoding of data in various sized bars using a variety of symbologies, or coding methodologies. The most familiar type of barcode is the UPC, or universal product code, which provides manufacturer and product identification. While barcodes have proven to be very useful, and indeed, have become an accepted part of product usage and identity, there are limitations with the technology. Barcode scanners must have line of sight in order to read barcode labels. Label information can be easily compromised by dirt, dust, or rips. Barcodes take up a considerable footprint on product labels. Even the newer barcode symbologies, such as 2D, or two-dimensional, which can store a significant amount of data in a very small space ("Two dimensional…," 2005) remain problematic. RFID proponents argue that limitations of barcodes are overcome through the use of RFID labeling to identify objects.

HISTORY OF RFID

Jeremy Landt (2001) wrote a history of RFID published by AIM, The Association for Automatic Identification and Data Capture Technologies, explaining that in the 20th century, the invention of radar took advantage of the electromagnetic energy that some postulate to have been present at the creation of the universe. By broadcasting and analyzing the reflection of radio waves, radar can identify two important characteristics about an object, its position and its velocity. This application of radio waves was a precursor to the use of radio waves in radio frequency identification.

During the 1950s, transponders were developed and improved, becoming increasingly more sophisticated and allowing for long-range determination of the identification of aircraft (Landt, 2001). Through the decades of the 1960s, 1970s, and 1980s, inventors, academicians, commercial enterprises, and governmental agencies explored a plethora of opportunities related to the use of early RFID devices, using radio transmissions, "short-range radio-telemetry," microwave technology, and radar beams (Landt, 2001). Landt states that RFID was first used commercially in the 1960s by companies that developed security related devices called "electronic article surveillance (EAS) equipment." Although EAS could only present the detection or absence of a tag, the tags were low cost

Figure 1. Barcode examples

314-34-1234

Code 39 (Source: http://www.idautomation.com/fonts/free/word-example.gif)

2 03489 34382 2

UPC-A (Source: http://www.idautomation.com/upceanfaq.html) and provided valuable deterrents to theft. EAS is still an important application of RFID today.

Work continued through the 1970s and in the 1980s, as companies began offering a variety of RFID related business solutions, primarily aimed at transportation, controlled access, and animal tracking applications (Landt, 2001). Of primary importance, in 1973 the United States government determined that there was no need for a national standard for electronic vehicle identification. This was serendipitous because it meant that individual firms, researchers, and others could have the freedom to develop new uses of RFID without being constrained by a governing body (Landt, 2001).

RFID TECHNOLOGY

Radio Frequency

Electromagnetic waves are comprised of a continuum of emanations, including visible light waves, and invisible frequencies such as television and radio waves, which are lower frequency than light, and x-rays and gamma rays, which are higher frequency than light. Frequencies are measured in Hertz (Hz), kilohertz (kHz), megahertz (MHz), or gigahertz (GHz), and represent the rate of oscillation of the waves. The portion of the electromagnetic spectrum used by radio frequency identification includes LF (low frequency), HF (high frequency), and UHF (ultra high frequency), which are all portions of the radio wave frequency bands, hence the term "radio frequency identification." An advantage of radio waves over visible light is that radio waves can penetrate many substances that would block visible light. Radio waves range from 300 kHz to 3 GHz (Hodges et al, 2003). Specific frequencies use is controlled by governmental agencies.

Some of the concerns relating to RFID are inherent to the technology upon which it is based. For instance, the range over which devices using radio waves can consistently communicate is affected by the following factors:

1. The **power** contained in the wave transmitted
2. The **sensitivity** of the receiving equipment
3. The **environment** through which the wave travels
4. The presence of **interference** (Hodges et al., 2003)

Hardware Components

The radio frequency transmissions in RFID travel between the two primary components, the **RFID reader** and the **RFID tag**. The reader can be mobile or stationary and is the proactive component. It consists of an antenna and a transceiver, is supplied with power, and generates and transmits a signal from its antenna to the tag and then reads the information reflected from the tag (Hodges et al., 2003). The antenna is used to send and receive signals; the transceiver is used to control and interpret the signals sent and received ("What is…," 2005). The tag, a transponder, is affixed to the object being identified, such as an automobile, a shipping pallet, or a tagged marine mammal. Thus, we can see a major benefit in using RFID since the data is exchanged using radio waves; it is not necessary to have line of sight between a reader and a tag, such as is required with barcodes. This permits a great deal more flexibility in the use of the RFID.

Although all readers have an external power source, tags may be completely without power or with some degree of power, and fall into three categories[1]: (1) **Passive tags** are inert; they do not have any power source and must use energy from the radio wave that

Figure 2. The electromagnetic spectrum (Adapted from Hodges, 2003)

AM Radio			TV FM Radio	Microwaves FM Radar				
LF	MF	HF	VHF	UHF	Infrared	**Visible Light**	Ultraviolet	X-rays; Gamma Rays
Low frequency *Long wavelength*								*High frequency* *Short wavelength*

is transmitted from the reader. This reduces the costs of the tags, but also reduces their performance. (2) **Semi-active tags** incorporate a battery which powers the electronic circuitry while the tag is communicating with a reader. Although the power is not used to produce radio waves, the power source improves the performance of the tag, most commonly by increasing the transmission range. (3) **Active tags** are fully powered by battery; they are able to generate radio waves autonomously, without the need for a reader to first transmit a radio wave. As power sources are added to these tags, we can see that their utility increases, but at the expense of the cost per tag, and so active and semipassive tags are generally reserved for higher-value items (Angeles, 2005; Hodges et al., 2003).

The tags consist of three components: antenna, silicon chip, and substrate or encapsulation material (Want, 2004). The antenna is used for receiving and transmitting radio frequency waves to and from the reader. The chip contains information pertaining to the item tagged such as part number and manufacturer. Chips can be either read-only or read-write; the costs are higher for the read-write chips. There is a crucial difference between read-only chips and read-write chips. Read-only chips are essentially electronic barcodes. Once the data has been encoded onto the chip, it cannot be modified and, therefore, cannot transmit information about the product as it moves through a sequence of events ("The Write Stuff…," 2003). A twist on the read-only vs. read-write chips is the EEPROM (electrically erasable programmable read-only memory chip). While individual pieces of information on EEPROM chips cannot be modified, the entire existing data on these chips can be replaced by new data (Angeles, 2005; Want, 2004).

Software

The RFID reader and tags represent just part of the entire RFID story. RFID is feasible only due to advances in database management and information technology which have allowed the storing, processing, and analysis of the data generated through RFID. Traditional barcodes require just the addition of the UPC code to the existing database of items. RFID, by virtue of its use of a computer chip, has the capability of not only storing static data, such as UPC codes, but also of storing dynamically created information, such as movement of the product through a supply chain. Early adopters of RFID are using current database and application systems and modifying them to accommodate the currently modest amount of additional data. However, the industry understands that RFID technology brings with it the promise of huge amounts of data to be managed, stored, and communicated.

RFID STANDARDS

Electronic Product Codes

Just as barcodes encoded universal product codes, RFID tags encode electronic product codes, known as EPCs. The EPC is a unique standard in that it is being systematically developed well in advance of its use rather than being cobbled together on the fly as has happened with other standards. The Auto-ID Center at MIT began the thought process to develop EPC. The original concept was that using RFID and EPC would permit an "Internet of things," a universe of identified objects that could be tracked, interrogated, and provide added value to supply chains by enabling granular information at the item level for every item, big or small, high value or low value ("EPC: The End of Bar Codes?," 2003). The Auto-ID Center has completed its pioneering work and passed the torch on to EPCGlobal. The labs of the Auto-ID Center are still in existence under the aegis of Auto-ID Labs (www.autoidcenter.org). EPCGlobal's focus is not only on the creation of EPC standards, but also on the creation of a global community of EPC users spanning a multiplicity of supply chains around the world ("RFID Implementation Cookbook," 2006).

Frequency Allocations

The frequencies used by RFID devices are dictated by the governments of the countries in which the technology is deployed. The management and allocation of specific frequencies for use by commercial and governmental agencies has been seen as a responsibility which should devolve to the government to control. As an example, Hall and Schou (1982) argued that what they called the electromagnetic spectrum was essentially a finite resource with strategic importance to national and international communication and to the national economy.

Figure 3.

SAMPLE PAPER LABEL WITH EMBEDDED RFID TAG
(Source: http://www.suppliersystems.com/rfid.htm)

(headings supplied by author)

With respect to RFID frequency allocations, governments are beginning to realize that it is also important to "harmonize radio communication systems" with other countries in order to benefit most fully from international trade. Developers and users of RFID need to become familiar with the legislation pertaining to RFID for their areas. It should be noted that even if there are conflicting frequencies assigned, in some cases it is possible for developers to obtain waivers to test RFID systems outside of assigned spectrums if the system being created is intended for use in another country (Hodges, 2003).

Governing Bodies/Testing and Research Facilities

Two primary governing bodies are involved with development of RFID standards. As mentioned earlier, EPCGlobal has taken up the development of standards from the Auto-ID Center. In addition, AIM Global (the Association for Automatic Identification and Mobility) is working with CompTIA, the Computing Technology Industry Association to develop an RFID certification that will be vendor-neutral and cover such items as "radio frequencies, interference, terminology, and standards" ("CompTIA…," 2005).

Independent testing and research facilities are also moving along the development of RFID technology. Examples include the nonprofit RFID Alliance Lab, based at the University of Kansas (Swedberg, 2006) and the University of Arkansas' RFID Research Center ("Researcher…," 2006).

Technology Development

Current research is concentrating on tags that are not affected by liquids or metals, and that permit the reading of closely packed tags such as would be used when tagging individual items in a retail situation. Early testing has indicated that Generation 2, known as Gen 2, UHF tags successfully fill these criteria. UHF, or ultra high frequency, permits near-field reading, in which the reader is close to the tag being read, in addition to far-field reading of tags. When transmitting in a near-field situation, the UHF tags transmit through the magnetic field; when transmitting in a far-field situation, the

UHF tags transmit through the electromagnetic field. However, others, particularly in the pharmaceutical industry, believe that HF, high frequency, tags are more efficient. The possibility of multiple standards looms as a concern for companies involved in multiple industry sectors (O'Connor, 2006).

RFID SUCCESSES

Transportation Industry

EZPASS is a well-known and well-accepted area of RFID technology use deployed in the eastern part of the United States. The EZPASS system was developed for a consortium of states wishing to automate the toll-collecting process on major highways, tunnels, and bridges. With the EZPASS system, motorists are issued a transponder which can be mounting on the inside of the front windshield. When the vehicle passes an EZPASS toll collection point, a stationary reader recognizes the serial number encoded in the transponder. This serial number is used to identify the motorist's EZPASS account, in which funds are held in escrow. The amount of the toll is automatically deducted from the fund. When the fund balance falls below a minimum amount, it is automatically replenished by charging a credit card account furnished by the motorist. Initially, motorists were induced to participate through discounts offered on tolls collected by EZPASS vs. tolls collected manually. EZPASS has reduced the number of toll takers and, in some instances, increased the throughput of vehicle traffic by allowing drivers to pass the toll collection station at speed. Although the transponders are bulky, they are easily mounted. While there is no charge for the transponders, motorists are responsible to return them when leaving the program; unreturned transponders are subject to a fee (Vavra et al., 1999).[2]

Supply Chains

Supply chains consist of manufacturers and retailers working together to provide product to the end consumer. Supply chain partners rely on close working relationships in order to increase the efficiency and lower the costs of moving product from the raw material stage through manufacturing to the final retailing of the merchandise. RFID is proving to be a valuable tool to this end.

Wal-Mart Corporation has been a major force in the deployment of RFID within supply chains. In 2003, Wal-Mart dictated that its top 100 suppliers must implement RFID to identify cases and pallets being shipped through the Wal-Mart distribution system by 2005 (Seideman, 2003). Early examination of the impact has shown that RFID has reduced Wal-Mart's replenishment cycle and increased inventory accuracy ("Study of Wal-Mart…," 2004).

Another retailer that has made significant contributions to the evaluation of RFID is Metro Group, a German supermarket firm. In its Future Store near Dusseldorf, Metro Group has tested products ranging from razor blades to cream cheese (Tarnowski, 2005). Marks and Spencer, a clothing retailer in the United Kingdom, has been successful in using RFID garment-tagging to increase its inventory accuracy ("Marks & Spencer," 2005).

Other Applications

RFID has already proven to be a valuable technology in a number of industries. Some other applications include asset tracking, condition monitoring, and fleet management.

The mining industry was an early adopter of RFID technology. One use of RFID tags in mining was in validating the correct movement of haulage vehicles. These vehicles have read only tags permanently attached to the vehicles dump bed. As a vehicle approaches a dump area, a reader validates that it is approaching the correct dump bed. Information concerning the transaction, including the vehicle number, the weight of the vehicle before and after the dump, and the time, are recorded automatically. Using RFID obviates the need for human interaction between the scales operator and the vehicle driver (Puckett, 1998).

Asset tracking is an important application for RFID. Scottish Courage, a major UK brewer, used RFID to track beer kegs. In the brewing industry, reusable beer kegs constitute a major expense; when kegs are lost or not returned, these costs escalate. By tagging kegs with RFID labels, Scottish Courage was able to cut its keg losses in half, defer the need for purchase of new containers, and improve the visibility of the kegs and products (Wilding, 2004).

Because the chips embedded in RFID tags can record environmental information, RFID is very useful in monitoring the condition of tagged items. The

United States military uses this feature to monitor the physical condition of munitions, which are very sensitive to heat, humidity, and physical shocks (IDTech Ex Ltd, 2003).

RFID CONCERNS

Technical Issues

RFID users have encountered limitations with its usage. Liquids and metals impede the transmission of radio frequency waves (Leach, 2004). These materials, known as dielectrics, cannot conduct electricity (O'Connor, 2006).

Another technical issue concerns the possibilities of collisions. Collisions can occur in two ways. First, if two readers are in close physical proximity, their signals can overlap and interfere with each other. Second, if tags are in close proximity to each other, a similar collision problem can arise. Anticollision schemes to address the first problem include programming readers not to read tags at the same time and setting up an additional system to delete duplicate codes. The second problem can be addressed by setting up a query and response requirement between tag and reader that will only permit a matching condition to proceed (Angeles, 2005).

Privacy Issues

A major concern surrounding RFID is a potential loss of privacy on the part of consumers who purchase items which have been tagged using RFID technology. Consumer privacy advocates question the possibility of firms being able to track consumers by the RFID tags embedded in clothing. This concern has led the EPC to dictate that tags must be equipped, at a minimum, with at least one method for nullifying the transmission of data (Ohkubo et al., 2005). It has been noted that the adoption of item-level tagging in retail supply chains has been slowed at least in part by this privacy concern.

CONCLUSION

RFID is a very exciting technology with huge potential in many applications. As the technology's cost decreases and it becomes more efficient, the use of RFID is expected to grow exponentially. With that growth, important questions need to be answered to address privacy and other social concerns about the information being provided by these very smart chips.

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OTHER RESOURCES

www.aimglobal.org

www.autoidlabs.org

www.epcglobalinc.org

KEY TERMS

Active Tag: Type of RFID tag that contains a battery power source that is used for all of its functioning. Active tags can autonomously produce radio waves without the presence of a reader.

Air Interface: Air, the medium through which radio waves are transmitted.

Alignment: How the reader is oriented to the tag.

Auto ID: Auto ID, also called "Automatic Identification," is a form of ICT that enables identifying information about objects to be gathered through the agency of scanners and readers. Auto ID encompasses barcodes, RFID, and similar tagging technology which can be read and interpreted automatically by a mechanical device. A bar code reader can interpret a printed bar code; an RFID reader can interpret an RFID tag.

Bar Code: Automatic identification technology that generally employs a series of black vertical bars separated by vertical white spaces as a method of encoding numeric and alphanumeric data. Commonly used forms of barcodes are placed on consumer goods to identify universal product codes (UPCs). Newer technologies of barcodes include 2D (two dimensional) which allow more information to be encoded using a smaller area. There must be a line of sight between barcodes and barcode scanners in order for information to be read.

Dielectrics: Materials, such as liquids, that are not able to conduct electricity. These materials interfere with the transmission of radio frequency waves.

EAN (13-digit UPC code): Provides more flexibility than original UPC code.

EAS (Electronic Article Surveillance): The use of an RFID tag to identify valuable property in order to reduce theft.

EDI (Electronic Data Interchange): The electronic transmission of business information from one supply chain member to another, using a standard data format and standard transaction codes. An EDI transaction, known as Advance Shipment Notice, or ASN, is being coordinated with data tracked by RFID tags on products moving through supply chains.

EPC (Electronic Product Code): Encoded on RFID tags and tied to a multiplicity of data concerning the object tagged. Standards are still being developed and proposed for EPC by EPCGlobal, an international organization devoted to creating a community of supply chain firms cooperating to consistent end-to-end partnerships of product movement and tracking.

Frequency: Frequencies constitute the rate at which electromagnetic waves, such as light, television, and radio waves, oscillate. Electromagnetic waves are comprised of a continuum of emanations, including light waves which are visible, and invisible frequencies such as television and radio waves which are lower frequency than light, and x-rays and gamma rays which are higher frequency. Frequencies are measured in Hertz (Hz), kilohertz (kHz), megahertz (MHz), or gigahertz (GHz), and represent the rate of oscillation of the waves.

Gen 2: Second generation tags. Uses ultra high frequency range of radio waves.

HF (High Frequency): The original range of frequencies used with case and pallet level tagging in supply chains. The signals exchanged between HF tags and readers are subject to attenuation due to dielectrics.

Passive Tag: Type of RFID tag that does not have a battery incorporated and therefore must rely on power contained in the radio wave transmitted by the reader. Passive tags are the lowest cost tags, but also perform at the lowest level.

Reader: One of the two components of an RFID system. The reader generates and sends a radio wave signal to the tag, and captures and decodes the reflected signal from the tag in order to identify the object to which the tag is attached. All readers have some power source. Also known as an **interrogator**.

RFID: RFID, or radio frequency identification, is a form of Auto ID in which radio waves are used to gather information from electronic tags attached to items such as vehicles, merchandise, or animals.

Semi-active Tag: Type of RFID tag with a built-in battery power source which provides power to the electronic circuitry while the tag is communicating with the reader. Semi-active tags do not have enough power to autonomously generate radio waves.

Tag: One of the two components of an RFID system. The tag, a radio frequency transponder, is affixed to the product that needs to be identified and is actuated by receiving a radio wave sent to it by the reader. See **passive tag**, **semi-active tag**, and **active tag**.

Transceiver: An electronic device which is both a TRANSmitter and a reCEIVER.

Transponder: Also known as a tag, a transponder electronically TRANSmits and resPONDs.

UHF (Ultra High Frequency): UHF is being tested with Gen 2 chips as a means of overcoming problems with RF tags because the UHF emanations are not affected by dielectric materials in the same way in which RF is affected.

UPC (Universal Product Code): UPCs are used to identify consumer goods and consist of a manufacturer's number combined with a product number. The manufacturer's identification number is assigned by the Uniform Code Council; the manufacturer can then assign its own product number.

ENDNOTES

1. Some sources simplify the types of tags into two categories: active and passive. See "What is Radio Frequency Identification (RFID)?, 2005
2. Information also based on the author's personal experience with EZPass.

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University Training on Communities of Practice

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INTRODUCTION

The term communities of practice (CoPs) has been coined by Lave and Wenger (1991) during their quests on apprenticeship from 1988. They considered some studies carried on in very different backgrounds and kinds of culture such as those of Maya midwives in Yucatan, Vai, and Gola tailors in Liberia, U.S. Navy boatswains' drill-grounds, butchers of some American supermarkets, and among the members of Alcoholics Anonymous Association.

The common denominator of these studies that has appeared relevant to Lave and Wenger is the presence of learning mechanisms not surveyed before by others scholars and not connected with the direct interaction between apprentice and master, but with the participation to a practice shared with other actors such as other apprentices, masters and journeyfolks.

Lave and Wenger have therefore considered learning as something strictly linked to the social practice and they have observed the mechanism, defined as "legitimate peripheral participation", according to which also the apprentices are considered members of the community, that they call CoP, so they are entirely legitimated to share its resources and experiences, to take part in discussions and to have an equal interaction with senior experts.

Sprung up in an academic background, in issues connected with the study of language and social interactions, the CoPs have quickly come to business world where they are becoming successful as support strategy for training by e-learning (Brown & Duguid, 1995), knowledge management tools (Profili, 2004) and, more in general, development perspectives for studies on organizational learning (Alessandrini, 2005).

BACKGROUND

Lave and Wenger's studies examine the social features of learning, in particular they have taken into consideration Vygotskij's (1980) works about the "zones of proximal development". This theory explains the possibility for the learner to carry out some tasks also slightly out of the learner's capacities field, using, with the learner's communicative mediation, the competences background of the learning group the learner is in.

However it needs to point out the fundamental difference between the situation of the communities of learning (CoLs), artificial environments where teacher and disciples' roles are well defined, and that of the CoP, real environments where experts and apprentices co-participate in the realization of shared practices.

More recent studies as those Engestrom's (1987)—Vygotskij's original works traced their origins during the 1930s—widen the range of concept application of proximal development zone, explaining it from a "collectivistic" or "social" viewpoint. Other authors such as Orr (1996) study in depth the individual and public identity coming out in working environments, by spreading "war stories" that are tales on particularly difficult applicative situations having been solved successfully by intuition or experience.

The exponential growth of Internet connections from the 1990s (Rosso, 2005) fosters the spread of virtual communities (Rheingold, 1993) and the transformation of CoPs studied by Lave &Wenger into communities where the face-to-face interaction is more often replaced by distance interaction with the consequent issues of the computer-mediated communication (Rivoltella, 2003).

A TRAINING EXPERIENCE ON COMMUNITIES OF PRACTICE

In the research work of LAOC (Laboratory of Organizational Learning and Communication), coordinated by Professor Giuditta Alessandrini from University of Roma Tre, has been experimented a specific training on CoPs during last three academic years. That was possible thanks to the starting up of a Community of Practice among people attending the distance Master GESCOM (Knowledge Management and Development in Human Resources) directed by Prof. Giuditta Alessandrini. The activity, coordinated by Prof. Giovanni Rosso, expert in Pedagogy of Work and researcher at the Regional Institute of Educational Research in Latium, has been composed of several phases according to a methodology (Wenger, Smith, & Stuckey, 2005) outlined by Etienne Wenger, one of the most important experts in this field.

The first phase mainly aimed at creating the community and giving rise to identities and sense of ownership. In fact a community is not a community of practice without the following three features (Wenger, 2001):

1. An *identity* coming from interests sharing and above all from its adherents' devotion and loyalty (*commitment*) towards community; in these conditions the community obtains a *collective expertise* and its members learn from each other.
2. An *interaction* within the community carried on by discussions, activities in common, mutual help. The interests sharing is a necessary condition but it is not enough so that a community of practice can exist: the interactive aspect is crucial and the engagement in joint activities has to be shared even if it can be discontinuous.
3. The presence of resources and *shared practices* as a result of the non-stop informal and dialectical comparison of the personal experiences at the community disposal. The development process of these resources can also be carried on unconsciously and unintentionally, but it can simply start up spontaneously thanks to the social relations among the other members of the community.

In order to stimulate people attending the course and arouse involvement and a sense of ownership to community, group tasks have been proposed, chosen every year in a different field of master's curriculum. Amid the conventional tools for on-line social interaction (Calvani, 2005) each group had a private *forum* monitored by tutor at its disposal, to discuss the work development and organization, and a reserved area for materials exchange and sharing (*repository*). On the contrary, a discussion area in the public forum was dedicated to the impressions and opinions exchange about the progress of the activity.

The interaction by private forums has been very strong, with an average of hundred messages for each group of six to seven people in the space of about three months. The public forum area dedicated to community has collected more than 300 messages in the same period. Some groups in the first academic year have developed a strong sense of identity that at first fostered them to chose a name able to identify their group and then to organize an association among people attending the course of all master editions. This activity has also permitted in this first phase to create the community *domain,* that is the area of shared contents and organized knowledge, typical of CoPs.

On the contrary, the second phase aimed at achieving the *practice* by studying the cases suggested by tutors or discussing specific situations linked to the work experience of people attending the course and that have been proposed by the participants. In this phase people attending the course have been also stimulated to have, depending on the context and their expertise, different roles (coordinator, mediator, novice) so that they could experiment the mechanism of the "legitimate peripheral participation".

By way of an example we describe briefly a proposed case regarding the difficulties into which a hypothetical Eng. Pressi runs, supporter of an innovative management where there is much regard for workers' training and development needs, during his role of human resources manager in a conventional company, managed by its owners, where the only way to stimulate workers has always been the recourse to premium pays. Eng. Pressi has organized training interventions and meeting chances (indoor gym for employers, social trip for workers), but his initiatives have not achieved the result expected of higher personnel productivity.

The proposed incitement has opened a lively debate among people attending the course who have interact exclusively online, in forum, using the repository for sharing those materials used as a support of each theory. In this second phase, in order to make the interaction conditions closer than those of a real CoP, people attending the course have been divided in groups of 10-12 units each. Some people with a direct knowledge of the subject due to their work history had the "experts" role whereas the others behaved as "apprentices", because their knowledge was only theoretical and achieved thanks to the master specific modules.

During the degree thesis preparation followed by Prof. Alessandrini and her collaborators, people attending the course were given questionnaires regarding their on-line interaction experience in general (Gabanella 2006) and that specific one of the training on Communities of Practice (Lolli, 2007; Sisti, 2006).

Most people attending the course seemed to be satisfied for what they have experimented, declaring that the suggested activities have been extremely important to learn to collaborate at a distance and to interact online successfully. These competences are very required in the work market, but there are not yet specific training paths to achieve them.

However the answers of the different questionnaires are not totally superimposable. Gabanella's questionnaire (2006) included a question about the possibility to communicate efficaciously at a distance by forum which most people attending the course have answered positively. On the contrary, the majority of tested people have answered negatively to the question dealing with the possibility to realize a community only by online interaction (Sisti 2006).

Maybe this contradiction can be explained considering that most people attending the course lived in Rome and had the possibility to see each other face-to-face with a higher degree of satisfaction.

The more recent degree thesis, that of Lolli, has verified a high degree of satisfaction about the whole training experience in the field of CoPs that is perceived as innovative and quite useful for future work.

FUTURE DEVELOPMENTS

The described experience is going to be repeated in the next master editions to construct a specific module for training on CoPs. The exigency to train Human Resources Managers both in companies and central and local civil service has suggested to determine, for the practice development phase, more general themes and not specific issues of several sectors to which people attending the master belong. In fact these people have already settled in the work world.

One of the analysis and debate proposals for next academic year is going to deal with the organizational welfare, because it is a fundamental element for the quality of life in the working environment.

CONCLUSION

The CoPs subject is becoming more and more important as a Knowledge Management tool (Profili, 2004) and a strategy for organizational learning (Alessandrini 2005), whereas studies and training experiences on CoPs are still scanty.

The innovative aspect of the experience we have realized does not lie in the attempt to cultivate a CoP as a tool for knowledge training or management, but in the purpose to carry out a training in situation on strategies to use so that a CoP can rise and be cultivated.

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KEY TERMS

Community of Practice: Groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly. You can interact face-to-face or by forum, e-mail, chat in a spontaneous and self-regulated way and members decide how often and regularly it is better to apply to themselves to that. Obviously it is possible to take part in several CoPs at the same time and that is why the structure and the substance of communities evolve dynamically. The term was coined by J. Lave &E. Wenger in the late 1980s.

Computer-Mediated Communication: A particular form of interpersonal communication where participants interact at a distance by computer, sharing textual messages synchronously (chat) or asynchronously (forum or e-mail). To counterbalance the lack of nonverbal elements of communication and their metacommunicative content, graphic elements representing emotions or moods, called *emoticons* or *smiley*, are used. The most widespread ones are :-) to indicate happiness, :-(for sadness, ;-) for "I'm joking". Other metacommunicative forms are the use of capital letters, that means speak loud or shout, and the strategic use of the punctuation marks such as dots or a series of question or exclamation marks (????; !!!!).

Knowledge Management: All tools, software and procedures, to manage the knowledge in an organization or community. The term, introduced in 1986 by Karl M. Wiig, at first was related to technological aspects of knowledge filing, retrieval and spread, but later it included Human Resources training and management policy fostering knowledge sharing and spread within the organization. The knowledge management philosophy goes together with the values, loyalty, cooperation and sharing system, that is at the roots of business culture.

Learning Community: A tool of collaborative learning based on the on-line interaction between students and teachers. The model, suggested by Brown and Campione in the early 1990s borrowing the paradigm of the research scientific communities, goes by participants' knowledge sharing and use of metacognitive strategies of learning considerations. Teacher has a support function with his/her disciples, fostering the peer tutoring and the reciprocal teaching.

Organizational Learning: A field of the knowledge studies in the theories on organizations that inquires into the ways and tools with which an organization learns and adjusts to the environment. Argyris and Schoen considered the fathers of the organizational learning, define it as a process according to which knowledge and experiences of each member in the organization are codified and stored as common background of the entire organization. The term does not stand for "learning organization" which, on the contrary, is related to the strategies to use in an organization, so that it can learn continuously and successfully.

Virtual Community: A social aggregation springing out of on-line interaction, on Internet, by forum or e-mail, of groups of people sharing a concern and usually having no face-to-face contacts. This kind of interaction simply aims at knowledge and opinions sharing, unlike CoPs where the forming of shared practices occurs. According to Rheingold (1993) the community exists when the public discussions last so long and with an emotive participation to create a net of personal relationships.

Using Dynamic Visualizations to Enhance Learning in Physical Geography

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INTRODUCTION

Physical geography is a domain where many misconceptions and learning problems have been reported through the years in all ages, from elementary education through to university level (Siegburg, 1987; Schee et al., 1992; Neighbour, 1992; Harwood & Jackson, 1993; Purnell & Solman, 1993; Forsyth, 1995; Keliher, 1997; Livni & Bar, 1998; Bartlett, 1999; LeVasseur, 1999; Gobert, 2000; Gerber, 2001, Verdi & Kulhavy, 2002; Morgan & Tidmarsh, 2004; Pedersen et al., 2005; Cooshna Naik & Teelock, 2006).

According to the literature, the problems that appear in Physical Geography teaching and learning can be classified in the following five categories:

1. **Terminology:** Students cannot describe geographic characteristics using geographic terminology (Harwood & Jackson, 1993; Keliher, 1997; Golledge, 2005).
2. **Interpretation:** There are misconceptions and difficulties in the interpretation and explanation of geographic characteristics and phenomena. This is quite often observed among elementary students (Schee et al., 1992; Neighbour, 1992; Livni & Bar, 1998; Pedersen et al., 2005).
3. **Language:** There is a difficulty for students to express themselves verbally, especially using geographic terminology. Pupils perform better using alternative methods, such as sketching geomorphologic evolution. There is not a problem in perception, but rather in the usage of language (Harwood & Jackson, 1993; Keliher, 1997; Gobert, 2000; Golledge, 2005).
4. **Symbols:** Misconceptions and difficulties arise from the frequent use of symbols for geographic characteristics rendering. Symbols mainly concern the color attribution of hypsometric levels, discrimination between mountains, hills, valleys and plains, catchment basins and erosion levels (Fredrich & Fuller, 1998; Nordstrom & Jackson, 2001; Livni & Bar, 2001; Verdi & Kulhavy, 2002).
5. **Static media:** Natural phenomena have a dynamic character that is difficult or impossible to be represented in a static way (Siegburg, 1987; Schee et al., 1992; Neighbour, 1992; Livni & Bar, 1998; Cooshna Naik & Teelock, 2006). Misconceptions mainly concern changes on the earth anaglyph and especially the phenomenon of erosion (Gregg, 2001).

The proposals for the solution of these problems can be classified in the following three categories, as the critical review of the preceding literature shows.

1. **Integrated learning environments:** The design and implementation of integrated learning environments involving active participation of the students is of major importance. Specific didactic goals and learning activities, as well as the elimination of cognitive overload resulting from the huge volume and density of information are also important elements.
2. **Diversity in expression:** Variety in the way students express themselves beyond the verbal method is proposed, both for the construction of geographic knowledge and for evaluation purposes.
3. **Experience enhancement:** The huge space and time scales concerning geographic phenomena are the main cause of misconceptions. Realistic representations with natural semantics as well as different spatial and temporal scales appear to offer a solution for the difficulties in physical geography teaching and learning.

Information and communication technologies (ICT) support integrated learning environments, diversity in expression, and experience enhancement.

This article presents a critical review of the ICT used in physical geography learning. It also proposes interactive dynamic visualizations with an example on the phenomenon of erosion, and presents the results of a qualitative empirical research involving elementary school pupils.

ICT IN PHYSICAL GEOGRAPHY TEACHING

Computer assisted instruction and learning (CAI, CAL) have been applied to geography education for more than 30 years. Integrated educational applications were developed during the nineties, with the first positive learning outcomes appearing only recently.

The main reasons are the late technological boom in graphics and spatial representations, and the delayed development of interactive computer-based educational environments dedicated to geographic knowledge construction.

We believe that physical geography is a domain of special interest for the design of CAI and CAL applications, exploiting spatial technologies and high resolution graphics. Various types of ICT are proposed for students' motivation and active participation in the didactic process.

Regarding the evaluation of CAI and CAL systems for geography teaching, the results are poor and mainly concern university students. A worldwide empirical research showed that the use of ICT in Geography education was limited, whilst featuring their effectiveness in geography teaching and learning (Gerber, 2001). This is also highlighted by the recent published work (Morgan & Tidmarsh, 2004; Golledge, 2005; Pedersen et al., 2005; Shin, 2006 and references therein).

The purpose of the review that follows is the search of the proper technological approach for the design of an integrated computer-based learning environment. Thus, the research papers are classified according to the type of technologies used in geography education.

Geographic Information Systems

Geographic information systems (GIS) provide a powerful environment for the management and presentation of geographic information using different levels for the representation of different types of information.

Nellis (1994) and Keiper (1999) reported on the difficulty in GIS use at elementary level. Even for university students the results were not encouraging when they were taught spatial skills using GIS (Chen, 1998). The same problems were found by O'Kelly (2000) and Lloyd (2001) in all educational levels. Huang et al. (2001) spotted the problems with GIS in their lack of three-dimensional visualization and interactivity. Kerski in his survey of 1520 high schools that use GIS software reported that the effectiveness of GIS in teaching and learning is limited (2003). Positive learning outcomes reported only recently by Shin in her study with fourth grade students. The author found that using GIS with a well designed instructional module helps students improve their geographic knowledge and map skills (2006).

Almost all the researchers propose constructivism as the pedagogical support concerning the use of GIS in education, proposing authentic learning activities. It seems that GIS are difficult to introduce in education and offer a limited method of geographic information representation for knowledge construction and metacognitive skills acquisition.

Internet Tools and Applications

Internet, Web sites and portals are a huge resource of dynamic information. Virtual universities, geological institutes, meteorological stations and satellites are some of the resources for geographic information. Their immediate exploitation in the educational process is often difficult, since the material is not provided through an educational context.

Suthren (1998) proposed the replacement of educational geomorphologic posters with virtual representations published in web pages. Although the author pointed out the exploitation of ICT in cases where other media are not appropriate, he simply transferred geographic information from a traditional to an electronic format. Hill and Solem (1999), Hurley et al. (1999) and Taylor (2000) summarized the value of the Internet as an environment for up to date content delivery, online hypermedia context, interactive evaluation, tool for communication and collaborative learning. The authors proposed online collaborative learning environments based on social constructivism. Harrison et al. in their large scale study on the use of ICT and its relationship with performance in examinations reported a relatively high usage of Internet to find geographic information (2004).

In general, approaches using the Internet as a tool for geography teaching have a technocratic point of view, emphasizing technologies and tools rather than pedagogy and instructional design.

Hypermedia Environments

Krygier et al. (1997) developed a hypermedia application for geography and earth sciences teaching based on linked multiple representations of information such as text, maps, tables and graphs. Their proposal followed the general guidelines for hypermedia educational software without special mention of geographic education principles. Kraak and van Driel (1997) proposed hypermaps, multimedia systems with geographic references. Results from the use of hypermedia software in geography education have been published by Boyle et al. (1997). Technology proved to be strong motivation for 54 geography students who developed a positive attitude towards ICT, but the learning outcomes were limited. Recently, Cooshna Naik and Teelock, in a study with pupils aged 8-10, reported positive results on their attitude towards a hypermedia application but not on learning outcomes (2006). Although pictures of any kind such as illustrations, photographs, animation, video, etc play an important role in physical geography, there is no much work on educational hypermedia applications. Overall, a theoretical goal of contributing to a cognitive theory of how students learn from multiple representations and a practical goal of contributing to the design of effective multimedia instruction have to be set in order to reach positive learning outcomes (Mayer, 2002).

Virtual Environments

Virtual reality technologies offer a new context for the development of educational environments, based on three dimensional spatial representations. An educational virtual environment is the virtual environment that has one or more educational objectives, provides users with experiences they would otherwise not be able to experience in the physical world and redounds specific learning outcomes (Mikropoulos, 2006).

Mikropoulos (1996) designed an integrated environment for physical geography teaching combining virtual environments, GIS and multimedia content. Virtual field trips have been proposed and used by many researchers and educators as an alternative approach to field work. Moore (1997) combined virtual field trips with multimedia content and geographic data bases and found positive learning outcomes with Geography students. Hurst (1998) with a similar approach had no such evidence. Stainfield et al. (2000) proposed interactive virtual field trips, temporal and spatial modelling, without, however, presenting any result from empirical studies.

Simulations and Visualizations

Simulations and visualizations in earth sciences teaching have been proposed since 1997 (Mitas et al., 1997). The poor learning outcomes observed, are mainly due to the lack of didactic transformation of the scientific knowledge, as well as the use of symbols (Edelson and Gordin, 1998; Friedman & diSessa, 1999). Simulations presenting geographic information through numerical data and graphs gave no positive learning outcomes (Pinto et al., 2000; Renshaw & Taylor, 2000). Marlino (2001) has proposed visualizations of natural phenomena, without reporting any learning outcomes. References regarding realistic visualizations using natural semantics without symbols have not been found, except the positive learning outcomes reported by Bellos et al. (2003) who exploited visualizations and virtual environments representing real and imaginary landscapes.

Several technologies and approaches have been designed for physical geography teaching and learning. The main problem is the lack of empirical studies for the evaluation of this software and the absence of results in terms of learning outcomes. The lack of a proper methodology for empirical studies in geography education had been noted since 1992 (Schrettenbrunner, 1992), confirmed in 1999 (Boehm & Petersen, 1999) and 2000 (Welford & Fouberg, 2000) and continues until recently (Cooshna Naik & Teelock, 2006). Although ICT support integrated dynamic environments, diversity in expression, and experience enhancement, it seems that the problems posed by terminology, interpretation, language, and the use of symbols are not yet sufficiently faced by any of the above approaches.

It seems that today's proposals of ICT in geography education are in accordance with Freeman's proposals (1997), which are:

- Resources for content retrieval
- Real situations modelling tools
- Tools for enquiry learning
- Communication tools
- Tools for measurement of natural phenomena.

We believe that these have to be integrated in educational environments with certain didactic goals and learning activities. Taking into account all the above, as well as the lack of positive learning outcomes from the ICT approaches in geography teaching, we propose the use of visualizations in physical geography learning.

VISUALIZATIONS IN PHYSICAL GEOGRAPHY LEARNING

There are two main difficulties in physical geography teaching and learning for pupils and students; the use of symbols for the representation of geographic information through various media and the static character of media. Researchers propose dynamic means for the study of geographic phenomena in space and time, without the use of symbols (Siegburg, 1987; Schee et al., 1992; Rose, 1996). They propose geographic information visualizations based on simulations, representing characteristics and phenomena in a realistic way. As the bibliographic review has shown, there are no references regarding the design, development and evaluation of computer-based educational environments supporting the above proposals.

The main component, as in any didactic process, is the didactic transformation. The proper didactic transformation, proposed in this article, is the simulation-based realistic dynamic representation of geomorphologic characteristics and phenomena.

We define a simulation as the representation of an object, a natural or social phenomenon by software, where the user may manipulate conditions and parameters for study purposes. A simulation causes the machine to respond mathematically to data and changing conditions as if it (the machine) was the same object or phenomenon.

A simulation in the learning process places the learner in situations similar to reality, providing real-time feedback to questions, decisions and actions. A simulation has to be interactive giving the capability for changing those parameters that are important according to the didactic transformation. A simulation has to motivate the learner through multiple representations in order to make the relationship between the parameters obvious to them. The results of a simulation can be represented through a variety of ways, mainly as numerical data and graphics. Simulations are powerful tools in the learning process through visualizations, defined as optical representations of information and mental images. Optical hermeneutic experimentation is what we mean by educational visualizations. Consequently, we argue that animations that are not based on modelling and simulation processes do not have a great value within the learning process.

The visualizations we propose follow the basic principles that are accuracy, representativeness, visual clarity and interest (Sheppard, 2001).

Our visualizations also incorporate the following attributes which we believe are of greatest importance in the learning process:

- **Natural semantics:** Visualizations are realistic representations without the use of symbols. They represent the natural terrain together with hydrography, flora and other factors affecting the landscape's evolution
- **Spatial scale alterations:** Geographic characteristics and phenomena are represented in small, screen size, scale
- **Temporal scale alterations:** Long geological eras are integrated in small time periods under the user's control
- **Exploration and investigation of alternative realities:** Students experience cognitive conflict and reach conclusions by inducing different scenarios for the evolution of phenomena
- **Experience enhancement. New experiences:** Visualizations enhance, or provide new experiences concerning phenomena which are impossible to study through field work because of their huge spatial and long temporal scales
- **Interactivity:** Students may change parameters involved in the simulated phenomena, investigate natural processes, foresee consequences and compare environments
- **Immediate feedback:** Students immediately discover the results of their actions
- **Multiple representations:** The combination of multiple representations such as visual and verbal, contributes to the learning process

- **Reusability:** Visualizations may be integrated in more than one context, depending on learning styles or needs
- **Hypothesis formation:** Dynamic visualizations provide a tool for hypothesis formation related to the geologic history of the simulated places
- **Evaluation of geographic theories:** The critical attitude towards computer models allows students to discriminate between models and reality and acquire a scientific attitude
- **Hypermedia environment:** The integration of visualizations in hypermedia environments combining multimedia content and learning activities, gives direct access to recourses for the support of the learning process.

Dynamic visualizations are more valuable in the learning process when they involve multiple representations, especially when they combine visual and oral information. Learners are more likely to engage in productive cognitive processing when corresponding images and words are presented at the same time. Simultaneous presentation increases the chances that corresponding images and words will be in working memory at the same time, thereby enabling the learner to construct mental connections between them. This cognitive processing should result in deeper understanding (Mayer, 2002).

There are two tensions on the proper role of modelling in the didactic process. One proposes the use of already-constructed models of phenomena for demonstration purposes, while the other forces students to construct their own models to describe phenomena (Wilensky, 2003). The pure constructivist point of view is the later one, but there are other intermediate states between the two above. One of these, exploited by Wilensky (2003) and proposed in this article, is the use of pre-constructed visualizations as investigative tools. They involve changeable parameters, allow the user to modify settings and conditions and study the model's behaviour. Two advantages of this approach are time saving and the necessity of low level computer literacy by the students.

In the following, 'landforms', an integrated educational environment that involves visualizations concerning the effect of running water, that is the phenomenon of erosion, is presented. The visualizations represent real phenomena using natural semantics and users may observe, manipulate and perceive the evolution of landscapes without symbols such as colour codes. An empirical study with 13 pupils investigates the role of the dynamic visualizations in their ideas development and learning.

LANDFORMS: EDUCATIONAL SOFTWARE FOR PHYSICAL GEOGRAPHY

The bibliographic review presented in the previous sections showed that although elementary pupils are interested in natural phenomena and have misconceptions about them, there are no references to the effect of running water on the earth's surface. Moreover, there are no references regarding the design of educational software on phenomena such as erosion and landform creation.

In a previous empirical research, we studied pupils' ideas about geographic phenomena (Bellou et al., 2001). The results showed that the majority of children aged 9-11 had a very limited understanding of terrain evolution. Children mainly faced difficulties in the following areas:

1. It was difficult to accept the idea that the terrain can dramatically change, so that a canyon may one day be transformed into a valley
2. They could not represent the different phases of the evolution of the landscape in time
3. They could not accept the causes of the formation of riverbed and Delta.

In order to overcome children's difficulties, we have designed and developed 'landforms', an educational environment comprising visualizations of the phenomena under study. The software has three main parts, dynamically presenting the transformation of a canyon into a valley, the erosion of a riverbed and the formation of a Delta. Each part consists of three sections. The first involves visualization with a time bar for moving forward or backwards in time or even freezing evolution at will. The second combines the visualization with an oral presentation describing the phenomenon under study. The last section consists of interactive learning activities some of which include visualizations.

The visualizations were created using four different software packages. Firstly, digital landscapes based on real data including the geographic characteristics under study, were created using a package for the creation of virtual landscapes (VistaPro 4.0). The landscapes were processed in image processing software in order for the appropriate landforms to be constructed. The landscapes successively manipulated by VistaPro in order to give a series of digital landscapes representing a realistic evolution of the landforms due to the effect of running water. After that, the digital landscapes were imported into morphing software in order for the temporal evolution of the landforms to be created in a form of dynamic visualizations. Finally, the visualizations representing successive time periods were connected using video processing software, to allow the final visualization to be produced. The result was in two forms. The first was the visualization with the time bar, for the user to 'move' in time. The second was the visualization combined with oral representation, a narration about the terrain's transformation. Figure 1 shows three screenshots from the visualization representing the formation of a river Delta, caused by erosion.

Figure 2 shows one of the interactive learning activities. The pupil manipulates and observes two visualizations simultaneously, trying to discover the factor that causes greater erosion. This specific example shows two visualizations representing the same landscape with (top) and without (bottom) plant coverage.

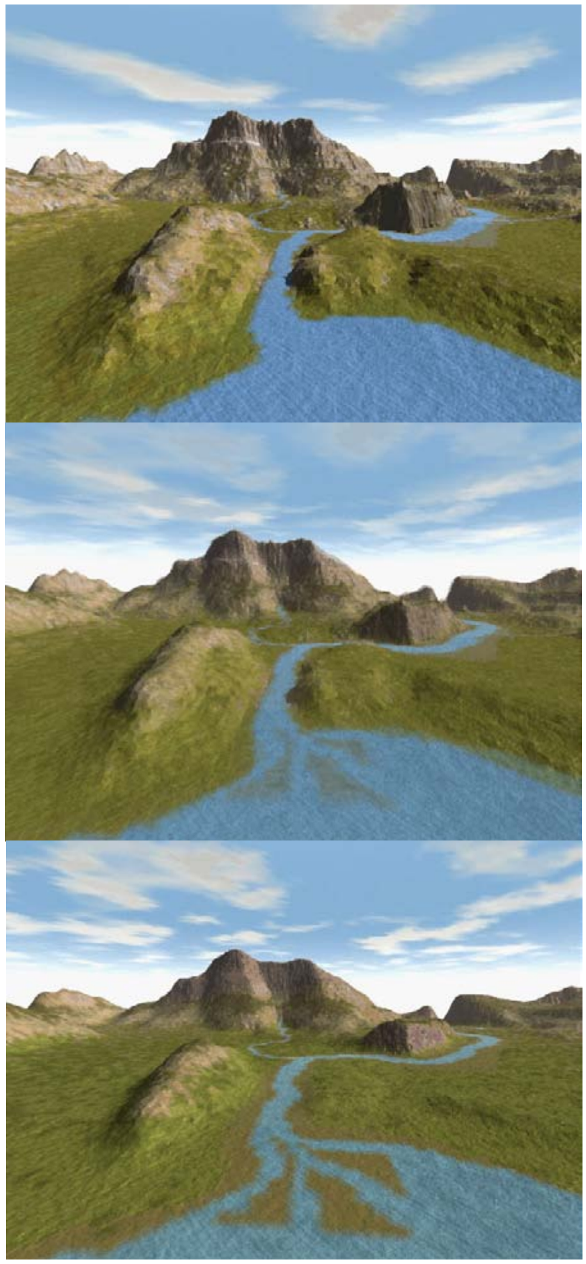
The educational software is integrated in a hypermedia environment involving a glossary of geographic terms as a reference. 'Landforms' is easy for teachers and pupils to use, without having any special expertise in computers.

THE STUDY

We used 'landforms' in an empirical study with the following research axes:

- Investigation of the pupils' initial ideas when observing the visualization as a succession of static images
- Investigation of pupils' ideas after their interaction with the dynamic visualization
- Study of the pupils' ideas development.

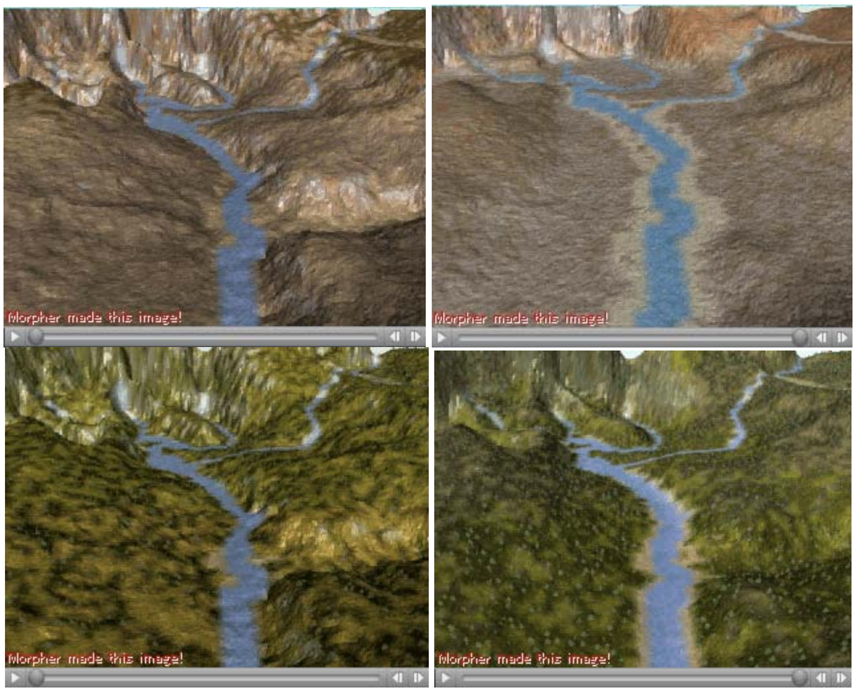
Figure 1. Three screenshots from the visualization representing the formation of a delta. Top: initial landscape condition, middle and bottom: intermediate and final landforms.



Sample

The sample was a class of 13 elementary pupils aged 10-11. All children had a basic level of computer use experience. The phenomena of erosion, deposition and river Delta were part of the elementary school curriculum.

Figure 2. A learning activity concerning the plantation as one of the erosion factors. Both visualizations represent the same landscape. The two upper screenshots show the initial and final conditions of the landscape without plant coverage. The two bottom screenshots show the initial and final conditions of the same landscape covered with rich plantation.



Procedure

The study was carried out in a real class environment, in the computer room. The procedure consisted of two phases. During the first one, each pupil observed the phenomenon of fluvial erosion deposition from a static visualization, a series of images. During the second phase, each pupil observed the same phenomenon as a dynamic visualization on the computer screen. During their interaction with the dynamic visualization, the pupils used the time bar of the visualization to 'move' in time, as well as the double presentation combining both visual and oral representations. They also completed a series of interactive learning activities. The only think the researcher did was to ask each one of the 13 pupils just after each phase to describe what they saw in the visualization and give explanations about the reasons for the changes they observed. Finally, they sketched the evolution of a landscape and the formation of Delta on a sheet of paper. A certain type of a landscape was already sketched, and the pupils had to sketch its evolution in two successive stages by themselves.

The research procedure lasted 45 minutes that is a one hour class.

Evaluation Methodology

It is considered that knowledge is the way of understanding a phenomenon and learning is a process of changing this way of understanding (Leung, 2000). Knowledge is described with qualitative terms that focus on the cognitive content of pupils' answers. The evaluation of pupils' answers shows that groups of pupils can be found to have the same level of understanding. Moreover, groups of pupils of the same age belong to different levels of understanding that build a level hierarchy.

SOLO (Structure of the Observed Learning Outcomes) taxonomy proposed by Biggs and Collis (1982), classifies pupils' understanding in the following five hierarchical levels.

1. **Prestructural:** The pupil avoids or repeats the question, makes an irrelevant association.

In a transitional stage, the pupil inadequately uses a relevant datum.

2. **Unistructural:** The pupil selects one relevant datum and closes on that.
   In a transitional stage, the pupil selects two relevant but inconsistent data.
3. **Multistructural:** The pupil selects two or more relevant data, uses them inconsistently and reaches an alternative conclusion.
   n a transitional stage, the pupil recognizes inconsistencies but can not resolve them.
4. **Relational:** The pupil uses most or all relevant data, integrates it with a relating concept and reaches the right conclusion.
5. **Extended abstract:** The pupil uses abstract principles that show the specific example is just one of many possible results.

We have used SOLO taxonomy for the data analysis of our qualitative study, which resulted in different hierarchy levels expressing the development of knowledge construction. An additional reason for using the SOLO taxonomy was its application in geography teaching (Biggs & Collis, 1982).

Each pupil's answer belongs to a level according to the following three components:

1. Detection of geographic characteristics and factors affecting the phenomenon under study
2. Association of characteristics and factors
3. Factual conclusion according to the above components.

We have detected the first four levels among the pupils' answers, showing their development of understanding when they first observed the static images and later after interacting with the visualization.

RESULTS

The results presented in this article concern only one part of the software, that of the formation of a Delta. Figure 1 shows three screenshots from the dynamic visualization. As the time passes, erosion caused by rainfalls and running water alters the landscape's morphology and the river's shape. The river transfers the eroded materials such as clay, slit and sand, deposits them at its estuary, and a Delta forms.

All pupils found their interaction with the software interesting, declaring no tiredness at all.

We have categorized pupils' answers into the first four SOLO levels, while we cite some of them below. We present each pupil's answer after the initial observation of the images and then after their interaction with the visualization. The question each pupil was asked was "What do you think is presented here? Why is this happening?"

Prestructural to Multistructural Level Answers

Georgia: "The river is shortening because the grass grows around the lake and the ground starts changing."

The pupil's answer was classified at the 1st prestructural level, since her description was extraneous to the matter in hand and focused on irrelevant details.

Georgia (after interaction): "In the beginning the mountains were big and afterwards they started lowering. The river was made by the rain and a Delta appeared."

Georgia's answer was classified at the 3^{d} multistructural level, since she observed the changes in the landscape, as well as the Delta formation. She neither connected the factors affecting the phenomenon, nor gave an adequate explanation.

Vasso: "As time passes some stones get out of water."

Her answer was classified at the 1st prestructural level. It could be at a transitional stage towards the unistructural level, since Vasso observed a datum, but did not consider the factors connected with the topic. Thus, she did not make any connection and did not explain any reason.

Vasso (after interaction): "As time passes the water runs, it washes stones out and a Delta is made."

Vasso's answer was classified at the 3^{d} multistructural level, since she reported some facts and reasons but did not explicitly explain the landscape's changes and the way the Delta is formatted.

Unistructural to Multistructural Level Answers

Sotos: "Water found some obstacles changed its course and the Delta was formed."

This pupil's answer was classified at the 2nd unistructural level, since he observed one datum, the Delta, but did not associated it with erosion.

Sotos (after interaction): "Heavy rains washed rocks and clay out and a Delta was made."

Sotos' answer was classified at the 3d multistructural level. It could be at a transitional stage between multistructural and relational, since he related the action of water to the Delta formation, but without giving any explanation.

Unistructural to Relational Level Answers

Thanos: "A Delta formation is presented. The running water has found some obstacles. So its direction changed."

This pupil's answer was classified at the 2nd unistructural level, since he chose one relevant datum and stopped at that. He did not associate data and gave no satisfactory explanations.

Thanos (after interaction): "The soil is washed out because of heavy rainfall and when the river reaches sea, it leaves some of the particles and loose stones."

After the interaction with the visualization Thanos' answer was classified at the 4th relational level, since he reported the sequence of the facts, their reasons and he constructed a complete argument.

Multistructural to Relational Level Answers

Tom: "Mountains started lowering. A river falls into the sea. The river washed mud out and it finally divided into four parts."

Tom chose certain relevant data, reported on them but he did not connect them. He used some ambiguous expressions concerning the outfall of the water and he gave a description without any explanation. So, his answer was classified at the 3d multistructural level.

Tom (after interaction): "The area was firstly eroded because of rain and snow. Materials were moved away by the river and a Delta was created during their deposition at sea."

Tom used most of data in a generic way, associated it in a consistent way, gave explanations and presented the relations between cause and result. This pupil, after the interaction with the visualization, constructed an argument and reached a scientifically correct conclusion. His answer was classified at the 4th relational level.

Simon: "It shows the changes coming from the river's water and the Delta formation."

Simon's answer was classified at the 3d multistructural level, since he described the phenomenon without explaining the way the changes occurred.

Simon (after interaction): "Water washed some materials out, and afterwards deposited them at the Delta. This way, the land expanded towards the sea."

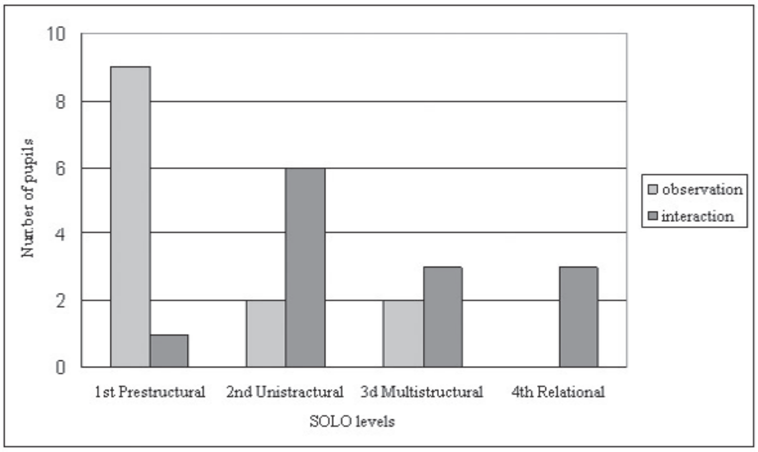
Simon's answer was classified at the 4th relational level after his interaction with the visualization, since he cited the facts in their order, associated them and gave explanations.

Figure 3 shows pupils' SOLO levels concerning their ideas on Delta formation both after the observation of the images and after the interaction with the dynamic visualization.

There was a shift in pupils' answers towards higher SOLO levels, after the interaction with the visualization. It seems that interactivity and multiple representations were strong attributes that contributed to reasoning, knowledge construction and meta-cognitive skills.

In order to by-pass the pupils' difficulties in language and the use of proper geographic terms, we studied their sketches showing the evolution of a landscape and the formation of Delta. The geographic characteristics the pupils had to change were the mountains, the river and the Delta. Eight out of the 13 pupils drew both the

Figure 3. SOLO levels concerning pupils' ideas about erosion and Delta formation, after their observation of static images and after their interaction with the visualization.



morphology and the Delta formation explicitly. The remaining five represented either the changes of the mountains and the river, or the Delta formation. All the pupils managed to overcome their language difficulties and express themselves by drawing the landform's evolution. Although sketches are not a simple direct representation of mental images, they are considered as an effective tool to interpret the pupils' internal representations and have been used to assess students' spatial concepts (Shin, 2006).

CONCLUSION

This article proposes the use of dynamic, interactive visualizations with natural semantics for Physical Geography learning. The author designed and developed the educational software 'landforms', involving dynamic visualizations in a hypermedia context. The article also presents results from a case study investigating 13 pupils' ideas on Delta formation both after their observation of static images and later after their interaction with the dynamic visualization. To our knowledge, this is the first work presenting empirical results from geographic dynamic visualizations representing phenomena in a realistic way without the use of symbols, following the proposals of many researchers (Siegburg, 1987; Schee et al., 1992; Rose, 1996).

The pupils' ideas improved after their interaction with the dynamic visualization and multiple representations. Their answers were shifted to higher SOLO levels, indicating knowledge construction. Initial ideas and misconceptions concerning the causes for Delta formation diminished. The pupils' ideas were shifted to scientifically accepted concepts that are that running water and river flow were the main causes for the anaglyph changes and Delta formation. There was not even one pupil who avoided answering. The pupils recognized all the geographic characteristics and their evolution in time. They mainly referred to terms from their everyday experience, which are integrated in the cognitive categories reported by Mark et al. (1999). The pupils' meta-cognitive skills were activated during their involvement with the interactive learning activities that they all completed correctly.

Positive learning outcomes after the pupils' interaction with the visualization were also confirmed by a series of the successive sketches they made, showing the landscape evolution and the Delta formation. This activity was designed for the children to be able to present their ideas without the geographic terminology which is difficult to use (Bartlett, 1999). These results are in coherence with those reported by Bartlett with students 13-16 years (1999) and by Gobert with pupils 10-12 years old (2000).

The results of the present study are consistent with those of others such as Friedman and diSessa (1999) who advocate representations as an important instructional target. The multiple and dynamic representations led the pupils to cognitive processing that resulted in deeper understanding (Mayer, 2002). Moreover, the positive learning outcomes are similar to those of the author's study with pupils using 'landforms' over a long period of study involving all three parts of the software, the transformation of a canyon into a valley, the erosion of a riverbed and the formation of a river Delta (Bellou, 2003).

The results of our case study highlight Friedman and diSessa's principles for educational visualizations in Geography learning (1999). Our dynamic and interactive visualizations support understandings of representational aspects, intuitive perceptual interpretive capabilities that are the central prior resources on which we seek to build, and allow pupils to design new representations that are an additional avenue of creative engagement.

We believe that dynamic and interactive visualizations with natural semantics, spatial and temporal scale alterations, exploration and investigation of alternative realities, experience enhancement, immediate feedback and multiple representations provide a powerful tool for hypothesis formation, evaluation of geographic theories and explanation of geographic phenomena. A hypermedia context with related information and learning activities is also proposed for the integration of the visualizations in an educational environment with specific didactic goals.

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KEY TERMS

Didactic Transformation: The transformation of high level abstraction symbolic codes used for the description of scientific models, in a way that optimizes their comprehension possibilities in the educational process.

Model: A physical or ideal system created to represent a physical or ideal system at certain level.

Natural Semantics: Representations without the use of symbols.

Optical Hermeneutic Experimentation: Visualization based on modelling and simulation processes by contrast to artistic representation.

River Delta: A low, watery land formed at the mouth of a river. It is formed from the silt, sand and small rocks that flow downstream in the river and are deposited in the delta.

Simulation: The representation of an object, a natural or social phenomenon by software, where the user may manipulate conditions and parameters for study purposes. A simulation causes the machine to respond mathematically to data and changing conditions as if it (the machine) was the same object or phenomenon.

SOLO (Structure of the Observed Learning Outcomes): Taxonomy proposed by Biggs and Collis (1982) that classifies students' understanding in five hierarchical levels. SOLO taxonomy is used for the qualitative analysis of empirical data.

Visualization: Construction of a visual image in the mind. A graphical representation of data and concepts.

Video Object Segmentation

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V

INTRODUCTION

Video object segmentation aims to extract different video objects from a video (i.e., a sequence of consecutive images). It has attracted vast interests and substantial research effort for the past decade because it is a prerequisite for visual content retrieval (e.g., MPEG-7 related schemes), object-based compression and coding (e.g., MPEG-4 codecs), object recognition, object tracking, security video surveillance, traffic monitoring for law enforcement, and many other applications. Video object segmentation is a nonstandardized but indispensable component for an MPEG4/7 scheme in order to successfully develop a complete solution. In fact, in order to utilize MPEG-4 object-based video coding, video object segmentation must first be carried out to extract the required video object masks. Video object segmentation is an even more important issue in military applications such as real-time remote missile/vehicle/soldier's identification and tracking. Other possible applications include home/office/warehouse security where monitoring and recording of intruders/foreign objects, alarming the personnel concerned or/and transmitting the segmented foreground objects via a bandwidth-hungry channel during the appearance of intruders are of particular interest. Thus, it can be seen that fully automatic video object segmentation tool is a very useful tool that has very wide practical applications in our everyday life where it can contribute to improved efficiency, time, manpower, and cost savings.

BACKGROUND

For segmentation of objects from video sequences, temporal and spatial information and their appropriate combination have been extensively exploited (Aach & Kaup, 1993; Bors & Pitas, 1998; Castagno, Ebrahimi, & Kunt, 1998; Chen, Chen, & Liao, 2000; Chen & Swain, 1999; Chien, Ma, & Chen, 2002; Cucchiara, Onfiani, Prati, & Scarabottolo, 1999; Kim, Choi, Kim, Lee, Lee, Ahn, & Ho, 1999; Kim, Jeon, Kwak, Lee, & Ahn, 2001; Koller, Weber, Huang, Malik, Ogasawara, Rao, & Russel, 1994; Li et al., 2001; Li, Tye, Ong, Lin, & Ko, 2002; Li, Gu, Leung, & Tian, 2004; Liu, Hong, Herman, & Chellappa, 1998; Liu, Chang, & Chang, 1998; Mech & Wollborn, 1997; Meier & Ngan, 1999; Mester & Aach, 1997; Neri, Colonnese, Russo, & Talone, 1998; Odobez & Bouthemy, 1998; Ong & Spann, 1999; Shao, Lin, & Ko, 1998a, 1998b; Toklu, Tekalp, & Erdem, 2000). Fully automatic extraction of semantically meaningful objects in video is extremely useful in many practical applications but faces problems like limited domain of application, *ad hoc* approaches, need of excessive parameter/threshold setting and fine-tuning, and overly complicated algorithms. With current level of development of algorithms, in general, only supervised segmentation approaches (e.g., Castagno et al., 1998; Toklu et al., 2000) are capable of detecting semantic objects more accurately from video. Supervised approaches can be found in applications such as studio editing and content retrieval.

Nevertheless, automatic video object segmentation is essential and possible for some specific but important scenarios like traffic monitoring, video-conferencing, and online/mobile security systems. For digital image and video storage and transmission, object-based coding improves the compression and coding efficiency. In low bit rate applications, object segmentation enables transmitting objects of interest in higher quality and objects of less importance in lower quality (e.g., allocating smaller number of bits for objects of less importance or only refreshing them occasionally, as used in sprite-based video coding), while a conventional frame-based video coding scheme would have to suffer an across-the-board reduction in video quality in order to fit into the bandwidth available.

The requirements for a practical video object segmentation system to be useful in the above-mentioned scenarios are: (a) fully automatic operations; (b) efficient and fast (preferably real-time) processing; and (c) robustness with noisy data. Automatic segmentation is necessary because user intervention is not feasible for real-time online applications. Appropriate domain knowledge (e.g., head and shoulder scene is mostly expected as foreground in video-conferencing) can be utilized in the process, besides spatial and temporal information. Real-time realization is usually needed for such applications and therefore low computational complexity is the key. Fast processing itself also aids in obtaining a better segmentation since frame difference due to the motion becomes too big for good segmentation if a segmentation process fails to catch up with the speed of live video camera input (unlike the case with prestored video sequences). Moreover, the segmentation module in an integrated system may need to share the available computing power with the video compression and coding module (e.g., Lin, Tye, Ong, Xiong, Miki, & Hotani, 1999) which is also computationally expensive. Furthermore, algorithms developed should be reasonably resilient to noise for reliable segmentation with live video. Possibilities can be exploited to incorporate appropriate stationary regions (e.g., human trunk that does not move all the time) with moving regions (like head and hands in the example) to form a semantic object.

Liu et al. (1998a) describes an object boundary extraction algorithm based on optical flow that is real-time implemented on a HyperSparc workstation. For the more restricted applications, real-time vehicle detection systems have been developed with dedicated hardware design (Cucchiara et al., 1999; Koller et al., 1994) and a PC-based platform (Siyal & Fathy, 1995). Such systems are based upon interframe difference analysis. Methods using optical flow calculation and other motion parameter estimators are generally too computationally expensive for economical real-time PC/DSP implementation.

There are various techniques for video object segmentation, but the faster video object segmentation techniques (Aach & Kaup, 1993; Cheung & Ramath, 2004; Kim et al., 1999; Liu et al., 1998b; Mester & Aach, 1997; Neri et al., 1998; Shao, Lin, & Ko, 1998b) are based on the change detection approach (with and without preprocessing to cater for global motion) followed by further postprocessing. However, the different video object segmentation methods differ in how the change detection and the postprocessing are being performed. These have a significant influence on the actual speed, accuracy, and reliability of the final segmentation results.

VIDEO SEGMENTATION: NEW AND OLD PROBLEMS

A general solution is still elusive in practice for automatic video object segmentation due to its well-acknowledged inherent difficulties: (i) the difficulty in estimating objects' motions and other distinguishing features accurately in order to facilitate the separation of differently moving foreground and background objects; (ii) the inevitable presence of noise/clutters that affects accuracy in segmentation; (iii) the effects of occlusions and dis-occlusions, causing dis-occluded regions to be wrongly labeled as foreground (moving) objects; (iv) the lack of generosity and robustness of an algorithm, especially in the situations in which no human intervention or fine-tuning of the segmentation parameters is possible; (v) high computational complexity involved which makes it difficult to design an algorithm that is robust enough to run in real-time for real-life applications; and (vi) for change detection methods, the stationary background frame obtained is nonrobust and not possible to obtain a good stationary background frame in real-life practical applications.

Spatiotemporal segmentation is more likely to obtain good segmentation for digital video when compared to methods using only motion information because spatial features usually provide more information on precise object boundary. There were many spatiotemporal approaches that have been proposed using change detection (Aach & Kaup, 993; Cheung & Kamath, 2004; Kim et al., 1999; Liu et al., 1998b; Mester & Aach, 1997; Neri et al., 1998; Shao et al., 1998b), instead of motion model/parameter estimation (Bors & Pitas, 1998; Li et al., 2001; Liu et al., 1998; Meier & Ngan, 1999; Odobez & Bouthemy, 1998; Shao, Lin, & Ko, 1998a; Ong et al., 1999) since the former aims at real-time processing and different motion in a foreground object does not need to be distinguished in the targeted applications (that is, a scene is separated into only two classes of objects: foreground and background). Temporal information is extracted via change detection as simple and straightforward hints of foreground objects and then spatial features are utilized for more accurate extraction of object contours. On the balance of incorporating multiple features for good segmentation (Castagno et al., 1998) and fulfilling the real-time requirement, the minimum set of the most effective temporal and spatial features (change due to motion, edge, and gradients) has been proposed (Ong, Tye, Lin, & Etoh, 2002).

Change detection is a fast way to extract moving foreground in video sequences with stationary cameras. However, the change detection method has the following drawbacks: (1) the correct threshold used in detecting interframe difference is not easy to obtain; (2) uncovered areas affect the accuracy of the change detection mask; (3) there are usually many *holes* inside the resultant change detection mask due to the less textured areas within a moving object; and (4) object contours are not accurate. Correct determination of the decision threshold will result in lower error probability and thus greater robustness against noise. However, the thresholds used in change detection are often set empirically (Kim et al., 1999; Mester & Aach, 1997; Shao, Lin, & Ko, 1998b) or determined off-line using prior knowledge of noise variance of the camera (Aach & Kaup, 1993). These approaches result in poor portability of the algorithm and can also be regarded as a kind of user intervention (Castagno et al., 1998). As a better approach, the decision threshold can be estimated online from unchanged regions with live video input. However, this is obviously very difficult in general because the unchanged regions cannot be found before performing change detection (in fact, separation of unchanged regions is the very aim of change detection).

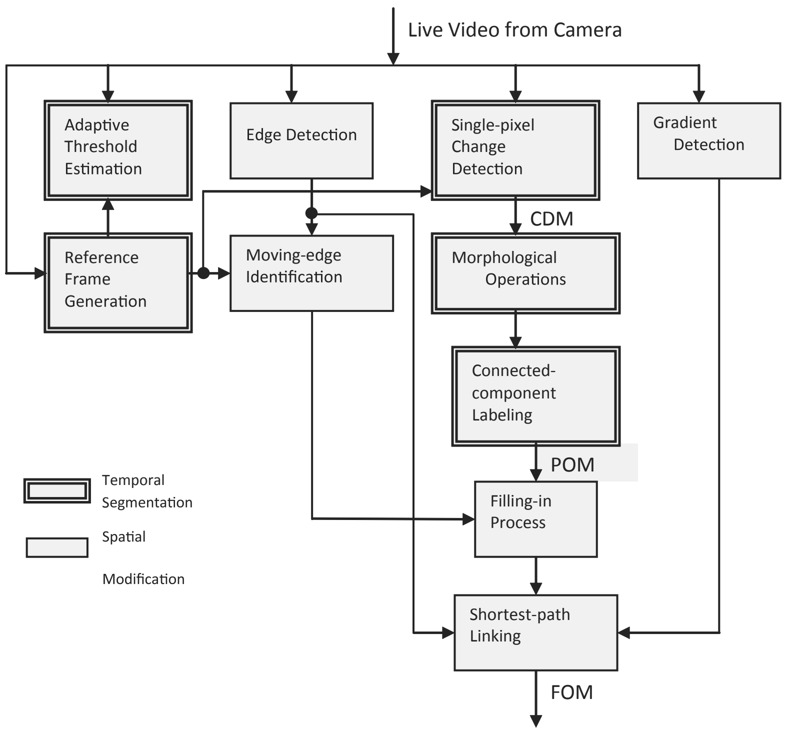
Ideally, the video object segmentation scheme should have a method of adaptively determining the threshold for fully automatic change detection (Neri et al., 1998) and also a much more efficient and robust criterion for online real-time manipulations (Ong et al., 2002). Ong et al. (2002) proposed a method where proper domain knowledge is utilized to choose the *most probably stationary pixels* (*MPSP*s) for the said estimation with at least 50% for the outlier tolerance in the candidate set of pixels. Thresholding here is performed at each pixel difference instead of a neighborhood of pixel difference (in contrast to the change detection processes in Kim et al., 1999; Liu et al., 1998b; Mester & Aach, 1997; Neri et al., 1998; Shao et al., 1998b) in order to eliminate the *blurring* effect and reduce computational cost. The change detection mask is eroded to alleviate oversegmentation caused by uncovered areas, and then modified with appropriate morphological operators (Vincent, 1993) to reduce the noise and holes inside the mask before forming a preliminary object mask to be passed for spatial refinement. The reference frame for change detection can be an immediate previous frame or the stationary background image generated in the initialization phase. The latter approach is able to solve the problems of dis-occluded regions appearing as part of the segmented moving objects. For the case in change detection where the reference frame is a stationary background image that has been generated in an initialization phase using a simple averaging, it is of paramount importance that there is no motion in the images being used to generate the stationary background image. However, in practice, it is very difficult or almost impossible to ensure that there is no motion during the initialization phase in real-life applications (in many situations where you have no full control over the environments, e.g., in traffic monitoring and video surveillance applications).

A fast, automatic, and reliable video object segmentation algorithm suitable for content-based applications has been proposed by Ong, Lin, Tye, and Etoh (2006) and illustrated in Figure 1. Targeted at the type of scenario with static camera, their algorithm has been shown to perform better than other related work in terms of both fault rate and processing speed. Their proposed algorithm may be extended for the cases with camera in motion because dominant motion can be detected (Kim et al., 1999; Mech & Wollborn, 1997; Shao et al., 1998a) and change detection can then be performed with the current frame and the motion-predicted frame. Nevertheless, the above extension of the algorithm of Ong et al. (2006) will increase the computational costs by quite a lot and render real-time purely software-based implementation difficult.

FUTURE TRENDS

To achieve fast/real-time, automatic, robust, and reliably accurate video object segmentation suitable for a wide range of real-life applications, such video object segmentation schemes are expected to have several characteristics:

Figure 1. Overall block diagram for the video object segmentation algorithm proposed by Ong et al. (2006)



1. Fast, robust, and reasonably accurate and reliable motion estimation (for applications which require segmentation of differently moving objects, such as in military applications) or adaptive change detection technique (for applications where the video only requires to be segmented into just foreground and background objects)
2. Spatial refinement to the motion mask (obtained from the above step) by incorporating spatial information to the temporal information since spatial information (such as edges) provides more accurate cue to the real object boundaries
3. Being able to correctly label dis-occluded regions as part of background object instead of being part of foreground object
4. The segmentation system has built-in knowledge similar to an expert system for better video object segmentation
5. More efficient, reliable, and accurate object tracking method so that objects are tracked and segmented from frame to frame rather than performing the full suite of motion estimation and segmentation processes completely on each individual frame

To achieve real-time realization towards online camera inputs, it seems that the change detection approach is the choice for temporal segmentation due to its efficiency, and direct single-pixel thresholding is used for further speedup and for avoidance of *blurring effect*. The algorithm should be fully automatic since user interference at any stage is not possible, and the threshold for change detection is adaptively decided without empirical selection or prior calibration for the camera used. The reference frame for change detection should also be autoselected from the immediately previous frame or the robustly generated background frame to allow optimum segmentation quality according to different circumstances. With the construction of the background reference frame, the algorithm is able to solve the problems of dis-occluded regions appearing as part of the segmented moving objects.

For the algorithm to be useful with live video input, robustness is another important consideration. An automatic threshold determination scheme for change detection compensates camera and environmental noise dynamically and ensures correct calculation when many of the pixels are not in motion. The same tolerance rate should also exist in the background frame generation. Use of multiple features (motion, edge, gradients, etc.) in different steps can allow inconsistent object boundary to be adjusted.

In any change detection process, the change detection mask can be obtained by performing change detection on the current frame and a reference frame. The reference frame may be the immediate previous frame (as in the case of the video object segmentation algorithms in Aach & Kaup, 1993; Kim et al., 2001; Mester & Aach, 1997; Neri et al., 1998, Shao et al., 1998b) or a fixed stationary background image (as used in Cheung & Kamath, 2004; Chien et al., 2002; Li, Huang, Gu, & Tian, 2004; Li, Luo, Huang, Leman, & Yau, 2005; Piccardi, 2004). The latter approach is able to solve the problems of dis-occluded regions appearing as part of the segmented moving objects (for the case of a fixed stationary camera). In this second scenario, a simple approach is to obtain the fixed stationary background reference frame by an initialization phase where several background frames are averaged to obtain the reference frame. However, in doing so, it is inherently assumed that there cannot be any moving object in the numerous background frames captured in the initialization phase. This is not good if the camera spans field of view where it is difficult or even impossible to ensure that there are absolutely no moving objects in the scene during the camera setup and initialization phase (e.g., in public places or common corridors or crowded areas where people/vehicles are moving across now and then). In order to remove such restrictions and solve the above-mentioned problem, a robust method which can tolerate moving objects in the images used for the initialization phase is required for reference frame generation. Such robust method should ideally have a high breakdown point (e.g., 50%) and also efficient in the presence of Gaussian noise, especially when a small number of samples (in this case, a small number of previous captured frames) is being used to generate the stationary background image in comparison to the use of a simple median filter (Cheung & Kamath, 2004; Piccardi, 2004). Cheung and Kamath (2004) studied the methods for generating a background model, such as frame differencing, median filter, linear predictive filter, nonparametric model, kalman filter, and mixture of Gaussian models. It has been concluded via experiments that median filtering offers a simple alternative with competitive performance. Piccardi (2004) reviewed the various background subtraction methods such as average, median, running average, mixture of Gaussians, kernel density estimators, mean-shift, sequential kernel density approximation, and Eigen backgrounds. The conclusion drawn is that it is difficult to assess which method has the best accuracy as there is no unbiased comparison with a significant benchmark. However, simple methods such as standard average, running average, and median can provide fast speed and also acceptable accuracy in specific applications.

Another desirable characteristic of good video object segmentation scheme is that it is able to adaptively select the best segmentation methods for the underlying video content characteristics on-the-fly and switches the reference frame between the generated background image and the immediately previous frame to allow maximum segmentation quality according to scenes being viewed and also to cater for significant changes in lighting and even accidental movement of the otherwise stationary camera, and so forth. When the generated background image is used as the reference frame for change detection, the algorithm will be able to solve the problems of dis-occluded regions appearing as part of the segmented moving object when large object motion occurs in the scene and thus obtain much more accurate segmentation results.

A good and practical automatic video object segmentation scheme should not require any training/learning processing for foreground object segmentation and in addition, no continuous background maintenance method should be used as such a method is bound to produce significant errors in unexpected situations due to unexpected and significant video scene changes which cannot be sufficiently taken into account (such as the more complicated learning-based foreground object detection and also the use of background maintenance method reported in Harville, 2002; Li et al., 2002; Li et al., 2004). Processing speed for video object segmentation can be improved further if foreground objects once segmented are tracked (instead of being segmented at every frame) for a fixed number of frames or until scene change is detected. However, care needs to be taken to ensure that such an approach does not compromise on the accuracy and reliability of the segmentation results.

Although the change detection based techniques are usually designed for segmentation of video captured with a stationary camera, they may also be extended for the cases with camera in motion because dominant motion can be detected (Kim et al., 1999; Mech & Wollborn, 1997; Shao et al., 1998a) and change detection can then be performed with the current frame and the motion-predicted frame. If different classes of foreground objects need to be discriminated with motion velocity, each resultant connected component in the object mask can be divided into multiple regions based upon spatial homogeneity (Li et al., 2001). Motion velocity for every region can be estimated and all regions are grouped according to a motion similarity measure (e.g., the one suggested by Li et al., 2001). This attempt is expected to be less computationally expensive than those using motion estimation for the whole image, especially when foreground objects occupy a relatively small portion of the image. Accurate motion estimation for whole image frame itself is a difficult problem, and although a reasonably good method does exist (Ong & Spann, 1999), such a method achieves good results at the expense of very high computational costs. Further research is required to obtain reasonably accurate and fast motion estimation technique which is suitable for real-time video object segmentation.

Last but not least, comprehensive and thorough comparison of different video object segmentation schemes that already existed is currently lacking and there are no common databases and benchmarks against which such comparison can be performed. The methods for measuring segmentation quality can be objective or perceptual. Although some initial work has been done in MPEG resulting in the creation of MPEG-4 informative segmentation tools (MPEG-4 Video Ver-2 WD, 1999), these are not comprehensive and are not freely available to the research community. Significant work is still required in establishing such common databases and benchmarks in order to help advance video object segmentation research.

CONCLUSION

Video object segmentation is a very useful and important tool that has very wide practical applications in our everyday life where it can contribute to improved efficiency, manpower, and system cost. Current fully automatic video object segmentation techniques are still suffering from a lack of the combination of accuracy (usually measured in terms of fault rate), robustness (being able to give good segmentation results for all sorts of video sequences with different underlying motion characteristics), and low computational cost (able to segment the video in real-time). The better and more accurate methods suffer from very high computational cost while those that boasts of very fast computational speed suffers from a lack of robustness and accuracy. It appears that significant research still needs to be done to achieve a fully automatic, fast/real-time, robust, reliable, and accurate video object segmentation suitable for a wide range of real-life applications.

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KEY TERMS

Background: A term to refer to the object that is of little interest or visual importance in an image.

Change Detection: A method for performing temporal/motion segmentation based on subtracting two images and labeling each pixel as “stationary” or “moving” using a predefined threshold.

Dis-Occlusion: A term indicating that a region which has been covered/obscured from view in the previous image has now become visible in the current image.

Foreground: A term to refer to the object of interest in an image.

Mask: A term for referring to a grey-level digital image used to represent the various regions (marked with different labels or values) that encompass the various video objects.

Motion Estimation: The process of inferring the magnitude and direction of motion in a visual scene from a video.

MPEG: MPEG is the abbreviation for “Moving Picture Experts Group” and this is a working group of ISO/IEC in charge of the development of video and audio compression standards.

Occlusion: A term indicating that a region which is visible in the previous image has now been covered/obscured from view in the current image.

Supervised Segmentation: The process of achieving final segmentation results with the aid of human guidance and input (this is in contrast to automatic segmentation where no human intervention and guidance is required).

Video: A term to refer to a sequence of consecutively captured images.

Video Object: A meaningful concatenated region in a digital video.

Video Object Segmentation: The process of partitioning a digital video into two or more meaningful regions, called objects.

Virtual Communities and Collaborative Learning in a Post-Graduate Course

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INTRODUCTION

One of the most interesting phenomenon in knowledge society is the growing of virtual communities (Rheingold, 1993). A virtual community may be transformed into a knowledge community and this at times becomes a good opportunity for continuing professional training.

Stakeholders and educational institutions are currently debating on how to design lifelong learning. The most promising among the proposed solutions, are those that cultivate network learning and communities where learners can actively manage their own learning, cooperating with others through negotiation, with the support of more expert colleagues.

A strategic issue in this framework is that of preparing educators to collaborate in a virtual community. The collaboration process however, entails a number of difficulties and requires careful organization. To be effective it needs to be set up on specific basic requirements such as strong motivation, participation, awareness, capacity to balance, tolerance, and creativity within the group. Moreover, when compared with f2f (face-to-face) groups, a collaborative network group which suffers the mediation of interaction context has to face the problems of social grounding, and requires group cultural development in order to address the issues related to the construction of knowledge.

In this chapter I will discuss some of the main issues arising from online collaboration, through the presentation of a methodological model of a post-graduate course based on online collaboration. The model was developed over the last ten years, and implemented at the Laboratory of Educational Technology (LTE) of the University of Florence, with the aim of promoting effective online collaborative learning groups.

CRITICAL ISSUES FACED BY ONLINE GROUP WORK

The theme of networked collaborative learning has received a lot of attention in these last years (Calvani, 2005; Calvani & Rotta, 1999; Dillenbourg, Baker, Blaye, & O'Malley, 1996; Koschmann, 1996; Roschelle & Teasley, 1995; Scardamalia & Bereiter 1992; Strijbos & Martens, 2001; Trentin, 1998). However, as noted earlier, collaboration is not an easy activity. Studies on face-to-face group work emphasize that there are some widespread preconceived ideas related to the theory and practice of group work (Quaglino, Casagrande, & Castellano, 1992). One of the most common is the belief that it is enough for a group of people sharing a common interest to receive work assignments and to make them necessarily work together. Instead, a group should be considered as a complex entity and a converging point for a variety of needs which can be either individual (security, identity, esteem, self-esteem), or collective (maintenance and reaching an objective, shared memories, sense of belonging), or institutional (obtaining economic and/or moral results, developing innovations and human resources). Good management, therefore represents an adequate response to the complex whole of needs at play.

Emotive dynamics too, play an important role. Group activity may be deviated by particular mental activity with strong emotional connotations. Conflict, for example, in the relational life of groups experience is a clashing between opposite forces which are expressed through antagonism, and cause long or short-term paralysis which take a great deal of energy and time to resolve.

Several dimensions can be distinguished in the life of a group, namely, an "inner" dimension (individual's myths and emotions), a "real" dimension which refers to what the group effectively does and produces such as interactions and documents; a "representational" dimension as related to cultural and cognitive models which give life (cultural life of the group, models, stereotypes); and finally, a "social" dimension, related to the sense of institutional belonging.

According to Quaglino et al. (1992), a prerequisite for a group to perceive itself as a group, is the development of the sense of belonging to a common entity. This is possible through the promotion and encouragement of interactions, aimed at favoring the sense of cohesion. It is this linking factor which stands at the basis of the birth of a group, characterized by the sharing of rules, and the sentiment of pleasure arising from relating with others, and being sustained and comforted by their presence. An ulterior passage requests reciprocal interdependence, which is the conscious acknowledgement of the other and of the other's diversity as a resource for the group. The latter must be conceived as an entity within which each person is able to give his/her own contribution and avail of the contributions of others. Interdependence must evolve towards integration between the single needs and the demands of the group, following a particular configuration which facilitates collaboration, and consists of the active participation of the group in a common project.

A great part of group problems are also found on the net, but with some differentiations (Calvani, 2005). The team building process will need some added details keeping in mind the specific features of computer-mediated communication (Bullen, 1998; Feenberg, 1999; Jonassen, 2000; Rourke & Anderson, 2002). A critical element for example, possesses the necessary technological expertise. This may not only represent a preliminary selective factor, but may also condition group dynamics since participants have different capabilities. Those technically advanced can even unconsciously dominate the others. The most vulnerable area however, is that of satisfying the needs of identity and self-esteem. Feedback from online group work participants is delayed since interaction occurs without nonverbal cues (looks, attitudes, gestures) and communication is normally relegated to written messages. As a consequence, the construction of one's own identity in relationship with "the other" becomes a more difficult process, especially if the participants have very little direct experience with working online. This slows down the team building process and its essential components. Mutual trust, self-esteem, the knowledge of being welcome, mutual understanding, and social grounding are elements that contribute to the construction of a social atmosphere and the "sharing of a group culture". Online socialization could form part of the same work process but cannot count on direct contact. It can therefore produce a sociality vacuum. It may then be necessary to dedicate specific moments to preliminary online socialization.

The types of mediums used, also hold an influence in many other ways. If on one hand these mediums free communication from the bond of spatial-temporal presence and amplify relational potentials, on the other they also cause dispersive and fragmented communication. Not being able to directly see the effects of our own actions reflected on the face of the person we are speaking to entails greater communication difficulties, above all in the quantity and pertinence of the messages. This may favor a fragmented dialogue or other undesired phenomenon like stress, soliloquy, "duets", or quarreling.

THE LTE POST-GRADUATE COURSE

The LTE at the University of Florence has been delivering post-graduate online courses on "Methods and Techniques for Network Collaboration" since 1998. The course lasts five months and provides blended learning, including three f2f meetings. Those registered usually number around 150 people, and are mainly teachers still in service.

Along the years, innovative elements have been introduced on the methodological and technological level with the aim of facilitating collaborative exchange. My following presentation of the general outline of the course will include the methodological and technological devices recently introduced to facilitate and improve collaborative work, facing the critical issues noted earlier.

The Course's Structure

The course is based on a five-phased model which is partially similar to the Salmon's Five-Step Model (2000). It gradually proceeds from individual study to sharing and collaboration/cooperation.

Phase 1 – Technological familiarization (1 month): The aim of the first phase is to verify if the single participants are able to use online communication tools and know the netiquette rules, and to allow them to explore the functionalities of the virtual learning environment.

The e-tutor is a crucial figure who will be able to give support to the participants on a technical level.

Phase II – Personal documentation (1 month): The purpose of this phase is to allow each participant to acquire basic knowledge in the field of a specific subject area. Each participant is asked to do research activity on the Internet and to produce a final report. In this phase as in the following phase, the e-tutor plays a significant role as content expert and moderator of online interaction. He/she manages the group and helps participants develop self-management capabilities decreasing his/her presence in the 5th and 6th Phases.

Phase III – Online socialization (20 days): In this phase the objective is to promote social grounding in order to start up collaborative activity and to give rise to collaborative groups. The participants enter into the virtual classroom, present themselves to their colleagues and launch ideas which may be the possible basis of project work. At the end of this phase the collaborative groups are constituted. Each group is normally composed of 5-7 members, one of which has the role of coordinator.

Phase IV – Cooperative project work (2 months): This is the most relevant methodological phase. The participants analytically define the objective and the themes to be taken up, and the nature of the tasks and roles the group may need. In this phase the coordinator carries out the important role of summing up the situation, stimulating the members of the group and so on. We shall return to this phase later.

Phase V – Metacognitive analysis (10 days): This phase aims at reflecting on the collaborative experience and evaluating the process and its results.

The model gives particular attention to the initial phase which aims at preparing participants for the task. The students find themselves facing a computer and may feel a sense of isolation, especially if they are not experts. This is often one of the major reasons why a participant might desert a task. It is therefore important to create a moment of personal training for technological alignment (technological familiarization), or compensations for gaps in the specific subject area (personal documentation). This is based on the idea that the participants' level of expertise must be homogeneous in order to have significant interaction on the cognitive level during the collaborative phase. Another important moment is that of the building of collaborative groups. This must be handled by an e-tutor expert in communicative and relational dynamics in order to facilitate the creation of a cohesive atmosphere and the group's sense of belonging. The socialization phase responds to the need of setting the grounds to enable the single person to see that single person as part of the group. The model, moreover, gives great importance to self-evaluation and self-reflection. Besides providing for a final phase oriented towards this aim, the participants are invited to consciously assume conversational roles in the cooperative project work phase.

Conversational Scripts and Roles

The analysis of roles, functions and conversational structures has already inspired technological research. Different models developed within the field of computer supported collaborative learning (CSCL) aim at creating support systems to conversation, favoring well-argued discussions and dialogues based on meaning negotiation (Dillenbourg, 1999; Jerman, Soller, & Muehlenbrock, 2001; Koschmann, Hall, & Miyake, 2002; Soller, 2001).

How do we obtain the identification of a role within a dialogue that is held on a web forum? A message can be characterized in its gist, which can be synthesized in expressions such as "request", "proposal", "acceptance", or "explanation". These conversations can be combined with a sentence opener or even a label (thinking type, TT) used in specific technological environment for collaboration (CSCL).

In the course's last three editions, we decided to set up the collaborative/cooperative online activity (IV Phase) by structuring the process through the use of the label or TT. The Discussion Module which was the Web forum used, was developed and implemented on Moodle by our technical staff. The functionalities typically present in CSCL were transferred to this open source platform. The Discussion Module is equipped with a certain number of TT. The participant is asked to choose the TT which best represents the meaning of the participant's contribution. The TT is normally used in a metacognitive sense. The TT instead, have been taken as tools to designate conversational roles, and as such, we have called them dialogue symbols (DS).

The function of the DS is to help participants consciously manage their own intentions in communication, position their interventions with respects to the group's interactions on the whole and make their own contributions more understandable to the other members of the group.

The DS suggest the assumption of dialogue roles that can be relevant in the process of collaborative construction of knowledge. An example of such roles could include: Questioner, Mediator, Informer, Proponent, Facilitator, Motivator, Opponent, Monitor, Compiler, Cybrary, or Disseminator.

To facilitate this activity a dialogue format composed of three "conversational script" sequences was suggested. A "conversational script" is presented in the form of a Web forum predefined with a particular set of DS.

The scripts and DS sets may obviously be different according to the specific objectives of the collaboration activity. In our experience, the three types of Web forums were used in three consecutive sessions and for each of them a particular conversation script was suggested: Informal Discussion, Knowledge Construction, and Critical Review (Table 1).

Table 1. The collaborative/cooperative process

GENERATIVE SESSION
conversational script: «informal discussion»

General features	Centrifugal and explorative feature of the discussion
Cognitive valence	Objective: to obtain a wide set of ideas and proposals, enrichments, *brainstorming*. A lot of exchange of information (*infobroker*) even in informal ways, open and free exploration
Relational valence	Objective: **INTERACTION/COHESION**, dealing with the achievement of a good level of interaction/ cohesion; development good interaction abilities and presence, acknowledgement as a group, etc. Also greetings, presentations, communication efforts are very important. The emotive and relational substrata must be created, with a basic cohesion for the sense of belonging to a group.
Individual awareness	During the generative moment, the single participant should ask himself: "Am I able to make myself visible to the others?", "How can I make myself be known and stimulate the others?", "Are my messages appropriate to group communication?", "Do I leave, through my readings, the mark of one belonging to a group?".
Group awareness	The group should evaluate itself on an overall level regarding participation, productivity and reactivity. Crucial aspects to be monitored in this generative moment are: - number of participants absent (all should be encouraged to speak and the average participation level should remain high); - number of readings of the various messages (everyone should read everything); - reaction time between messages (2-3 days should not be exceeded).
TYPE OF WEB FORUM	The web forum **Informal Discussion** is chosen and is equipped to favor immediate communication, by stimulating participants in the initial phase to open out. The group members must socialize, overcome diffidence and initial anxiety, and rapidly and intuitively gather ideas, food for thought, work suggestions, and as many ideas as possible in order to identify a theme for discussion.
Dialogue Symbols available on the web forum	**Greetings, Proposal, Enrichment, Agreement, Disagreement, Encouragement** **Greetings:** I present myself, I wish to familiarize, socialize **Proposals:** I give some proposals, or a simple clue to be developed **Agreement:** I give my comments in favor of someone else's idea **Disagreement:** I give my negative comment on proposals given by others **Enrichment:** I add some information or a theory to the discussion theme **Encouragement:** I express a positive emotion or give my emotional support

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Table 1. continued

Constructive Moment
Conversational script: «knowledge construction»

General Features	Centripetal character of the discussion
Cognitive valence	Objective: to achieve a well-defined purpose centred on two main points, with intervals of observation, measurement, reminders, explanations.
Relational valence	Objective: **INTERDEPENDENCE/ COHERENCE**, dealing with the development of interconnecting relationships, through the "weaving" of dialogue and "coherent" topics (e.g., question-answer relations, reasoning, counter deductions or explanations, deepening, etc.). The important thing is the frequency of proposals followed by deeper explanations. What matters is the alternating of roles (e.g., questioner, clarifier etc., also infobroker – the exchange of information in this case is taken as an answer finalized for specific requests).
Individual awareness	During the constructive moment, the single participant should ask: "Am I succeeding in taking on opportune role that increases the interdependent network of the topics?", "Am I able to act in such a way that questions, suggestions that arise do not remain without an answer, but that they are adequately sustained or rebutted?", "Do I manage to alternate the different roles with the aim of favouring a good level of discussion?".
Group awareness	Does the group as a whole have a good coherence level? Do the critical sequences open out, develop and end adequately? Are dispersions and inconclusiveness avoided? The crucial aspects to monitor in this constructive moment are: - the production of coherent sequences, whereby coherent sequences mean a series of interventions labelled with "Question" or "Proposal", followed by interventions labelled with "Answer" (or "Enrichment", "Evaluation", "Connecting", Clarification"); - the arising of alternating flexibility of roles (proposer, counselor, integrator etc.) on behalf of various members; - the presence of interventions labelled with "Synthesis" in the final step of the discussion.
TYPE of WEB FORUM	The **Knowledge Construction** web forum is finalized in the production of a sufficiently structured document. The theme was already defined, and it now has to be discussed fully in a coherent and structured way. Concepts are proposed, integrated, corrected, in favour or against, converging towards a document that takes all the contributions into consideration.
Dialogue Symbols available on the web forum	**Question, Answer, Enrichment, Evaluation, Linking, Clarification, Organization, Synthesis, Encouragement** **Proposal**: I propose an idea or a hypothesis which the members of the community may agree with or not **Question:** I introduce a problem or a question which needs to be answered **Answer**: I answer a question posed by others **Enrichment:** I give other ideas or reference data that may integrate or perfect what has already been said in the discussion **Evaluation**: I express ideas in favour of or to rebut, with arguments to justify or support my opinion **Linking**: I integrate an issue or point of view with another issue within the discussion **Clarification:** I answer an issue or clarify it by discussing a point left open **Organization**: I propose rules or reminders to respect time tables and standards **Synthesis**: I take stock of the situation, summarising the diversity of elements that emerged. **Encouragement**: I express a positive emotion or an idea or give emotional support

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Table 1. continued

Critcal Review Moment
conversational Script: «critical review»

General features	Critical-analytical characteristic of the discussion
Cognitive valence	Objective: this moment should lead to a critical examination and analytical review of a document/ project already elaborated, or a tested product.
Relational valence	Objective: **INTEGRATION/REVIEW**, dealing with the achievement of a first organic restructuring of material and ideas already gathered in unified solutions, valorising everybody's contributions, not only as a simple "collage", but as a review effected by more examiners, covering different roles.
Individual awareness	The single participant should ask: "Do I manage to favour a critical and organic reviewing of the material already produced?", "Do I, in my role as critique, give a *finishing* touch in this process?".
Group awarness	Does the group as a whole manage to converge in a document (or product) critically reasoned out?
TYPE of WEB FORUM	The web forum **Critical Review** is adapted to a rigorous review in some aspects of residual critique. The group now is able to look at a product or a text. They must now review some parts analytically, to evaluate the possible alternative modifications. The critique level required is much higher and must be sustained with authentic roles. Some of the members are alternately assigned to critically examine and assess the document.
Dialogue Symbols available on the web forum	**Proposal, Critique, Additions, Review, Synthesis.** **Proposal**: I suggest a correction or modification of the text (object, product) **Critique:** I play the role of "devil's advocate" identifying existing criticism or unsolved antinomies **Additions:** I insert a piece that may perfect the existing product **Review:** I "reread" the text to express the possible modifications in an analytical way **Synthesis:** I complete the product and make out the clean document (object, product), and its final presentation

CONCLUSION

Online collaborative activity appears to be very complex. We believe that some critical factors for its success are:

1. Reducing the initial gap to favor an adequate familiarization level with the contents, technology and techniques of network communication;
2. Favoring the team building process and promoting a social atmosphere and group culture;
3. Identifying in detail the collaborative commitments with respects to timing, roles and interaction methods;
4. Developing awareness in the single components with respects to the specific relational and cognitive contribution offered to the group and by the group in relation to its capacity to think in terms of "we".
5. Capacity to handle the collaborative interactions and monitor them constantly so that the final activity results to be functional, and also reinforce and consolidate the constitutive dimensions of the group.

A careful evaluation of these factors and an adequate integration between methodology and technology are essential to significant learning experiences.

The course we have presented is based precisely on the need to satisfy these various requests. Continued reflection on and testing of the models towards this direction appears to us as one of the most promising paths for research in the sector of networked collaborative learning.

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KEYWORDS

Collaboration/Cooperation: In the studies on collaborative learning the terms collaboration and cooperation are usually distinguished from each other. The former refers to a working together of a group towards a common objective through mutual interventions and sharing, and the latter refers to the joint effort of a group towards the achievement of an objective through strategies based on the partitioning of work. This distinction is not to be taken as dichotomy. In reality cooperation and collaboration can be seen as two activities that place themselves along a continuum. In some cases, especially for collaborative online activities, a certain degree of structuring may be necessary.

Collaborative Learning: Research has widely deepened the concept of collaborative learning. The expression "collaborative learning" can be defined broadly as an instruction method in which learners work together in small groups towards a common goal. It means that students are responsible for their own learning as well as that of the others. Thus, it promotes peer-learning and tutoring.

Conversational Script: A conversational script can be intended as a complex path of pertinent communicative interactions in a certain stage of collaborative work, which is consciously assumed by a collaborative group as hopeful reference of interaction.

CSCL (Computer Supported Collaborative Learning): It is a field of research promoting the development of web technologies supporting teaching and learning models based upon collaborative learning.

Thinking Type: It is a scaffold label often implemented in the Web-based groupware for Computer Supported Collaborative Learning in order to support online discussions in the Web forum, facilitating reflection and metacognitive processes. Every time the user posts his/her message in the Web forum, he/she has to attribute a label (or thinking type) to his/her message according predefined categories.

Virtual/Online Community: It refers to a group of people that primarily interact via a computer network. The term is attributed to Howard Rheingold (1993). Even if it still does not exist an universal definition for this term, it can be defined as a social network with a common interest or goal that interact in a virtual space across time and geographical boundaries and is capable of to developing personal relationships.

Virtual Learning Environment (VLE): It is a Web-based software system designed for the management of educational courses. They are often also referred to by the acronym LMS (learning management system).

V

The Virtual Identity, Digital Identity, and Virtual Residence of the Digital Citizen

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INTRODUCTION

Since cyberspace appeared (Gibson, 1984), our existence has been endowed of a new dimension: "the *virtual*". This new "space", open to many interpretations, has been recognized as a philosophical category, becoming a subject of passionate speculation by many thinkers: Deleuze, Lévy, De Kerkchove, Maldonado—to cite just a few of the recent ones, but one could recede even to Aristotle and Plato.

However, if we leave the conceptual level, we realize that today "the virtual" exists for us because something very real exists and is surrounding us: technologies. We shall discuss this view and the effect that "the virtual" and the technologies associated with it have produced on us: the birth of three new attributes for any individual living in the digital society, a person's *virtual identity*, *digital identity* and *virtual residence*.

In the past, information and communication technologies (ICTs) worked exclusively as agents of transformation of the corporate and business worlds. For a long time Internet and the Web behaved as places for blurred, faceless crowds. Then, in less than a couple of decades, and with a sudden acceleration, the impact has shifted to the individual. A specific set of emerging technologies (e.g., wireless, locative and micro/nanotechnologies), is affecting the private, intimate sphere of the individual, where identity, reputation and privacy reside. At the same time the virtual and real dimensions begin to mix and sometimes even to collide.

There are currently many efforts to understand, define and manage the three attributes mentioned above. They are becoming essential *possessions* of man in the digital world, while the complexity of the issues relating to them proportionally increases. It is therefore convenient, before we delve deeper into the subject, to set up some provisional, informal definitions (see Exhibit A).

IDENTITY

First of all, what is the concept of "identity"? This term, already confusing in the real world, risks to be all the more so in the virtual world. There is an entire *European Network of Excellence* dedicated to exploring this concept, FIDIS (2005), "*Future of Identity in the Information Society*" (http://www.fidis.net). One of its key researchers attempts a basic definition:

Identity has to do with the characteristics of the individual, and what makes it unique or on the contrary similar with the others. Identity can be defined from an internal perspective or in the perspective of its interaction with the environment. (Nabeth, 2004)

The notion of identity affords many levels of complexity in its wide semantic field and it is a changing one (Rost, 2003). It is a composite concept, as represented in Figure 1.

Exhibit A.

Virtual identity	"*iPod, therefore I am*": this is how the young generations, roaming the digital sound spaces, state their identities (quoting Apple's CEO Steve Jobs on his cult music player).
Digital identity	The representation of a human identity that is used in cyberspace to interact with machines or people
Virtual residence	An attempt to establish in cyberspace an equivalent of "domicile"" in the off-line world

Information and communication technologies have shaped the concept of "identity" in a digital world by applying, the attribute "virtual" to the headwords of identity: "I", "me", "self", "persona". The result is called *virtual identity* (VID).

VIRTUAL IDENTITY (VID)

Does "virtual" mean "immaterial"? Let us look at some examples of the modern generation of *avatars*. For instance when, inside a fantasy world, they introduce themselves to their community, as "Elewin Lamfeu" or "Adsarta" in the *Encyclopédie de l'Héroïc Fantasy* (Fantasy-Archives, 2007). Let us take notice that there exists on the Web an "avatar service", which moulds a 3D animated character on the user's specification, with body, face, clothes and with the addition of all possible accessories (Meez, 2007); or the "selling of avatars", pretty images ready to be downloaded into our cell phones (Chameleon, 2007).

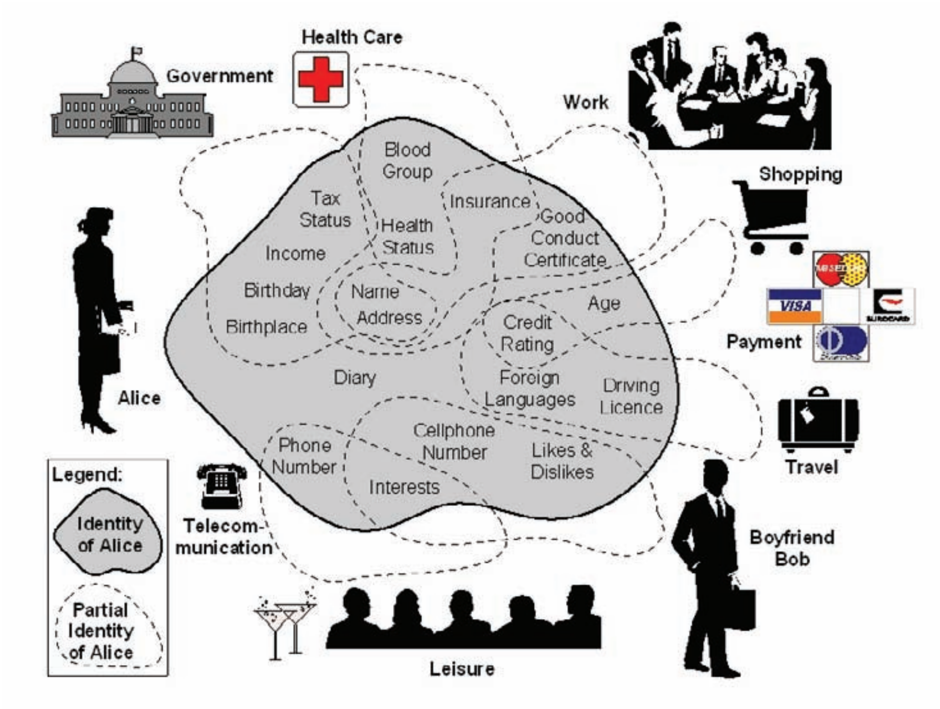
So great is the strength of the presentations, the liveliness and effectiveness of these digital creatures, that we become uncertain whether we are in front of fictitious and unsubstantial entities, that is, virtual ones, or facing a different case. Perhaps we are witnessing a graft of realities of different grades or a *second reality*, a new existential state that surreptitiously slips between the real and the virtual as we usually understand them.

VID is born when "online identity" is born, simultaneously with the first computer game, named MUD (Multi User Dungeon), the famous 1978 EssexMUD (UCSB, 2007). This reference is also adopted by the researchers at the large European project PRIME (*Privacy and Identity Management for Europe*, https://www.prime-project.eu/), who have done a very thorough terminology effort on the galaxy of notions pertaining to identity. Quoting in summary form some of their work (Pfizmann & Hansen, 2006, pp. 24-25), we have:

«Virtual identity.

Virtual identity sometimes is used in the same meaning as digital identity or digital partial identity, but because of the connotation with "unreal, non-existent, seeming" the term is mainly applied to characters in

Figure 1. Representing the identity and partial identities of Alice (Source: Clauß & Köhntopp, 2001, cited in FIDIS document (FIDIS, 2005, p. 20))



a MUD (multi user dungeon), MMORPG (massively multiplayer online role playing games) or to avatars. Often used to describe online contexts such as chatrooms where the subject of the identity does not wish it to be linked with offline identities. Thus the identity is exclusively electronic. »

The main perspectives in which we analyze the notion of VID are:

- Virtual identity as a mode of being, as a new social entity stemming from a history of technological events;
- Virtual/digital identity viewed as a management issue, caused by the multiplicity of relations and interactions of the individual with the virtual/real world;
- VID from an evolutionary point of view: how this electronic form of identity and all the other digital resources belonging to us will play when, in the future, we shall be moving across increasingly digitalized environments.

To develop the first point aforementioned we call out a sequence of scenes belonging to the evolution of the VID in time.

1st Scene: MUDs and Avatars

Although the technological foundation of MUDs (multi user dungeons) is very simple, the very high creativity of the authors and the fantasy of the players make them very attractive still today, when the sophistication of computer software is very high. MUDs were games which triggered many questions with scholars in many fields. Sherry Turkle, the renowned MIT researcher, stands out as being the first to look deeply into the virtual aspects of the "persona" of the players. A fundamental remark by her is, that it is the first time in human life that people have to take themselves "*at interface value*", that is, not for what they are, but for what they appear on the surface of a computer screen (Turkle, 1995, p. 103; 1998). It is the opacity of that interface that allows the possession of multiple identities that can be obtained—differently form the real world—with very limited means and in total freedom.

2nd Scene: E-Mail and Chat

With e-mail and chat the individual turns into pure writing. An important step in building one's identity is the choice of one's "nick", which intentionally may, or may not, reveal something about its owner. E-mail and chat are the realm of CMC (computer mediated communication), a completely new dimension of socialization. Therein body, looks, social status are obscured in the identity and the only element that determines success or failure when dealing with others, is the *word*.

3rd Scene: Virtual Communities

In the early 1990s the abundance of communication tools changes the landscape and gives rise to a generation of virtual identities which are richer and much more easily articulated. Virtual communities, since Howard Rheingold's definition (1993, p. 4) as "social aggregations that emerge from the Net", have greatly multiplied as places of deeply shared ideals and knowledge. Here the behavior is almost the opposite than in the previous scene. Identity is not hidden or camouflaged, but rather put forward, to assert one's personality, to gain a strong role in a discussion, to enter participation.

4th Scene: The Blogosphere

The beginning of the new millennium marks the transition from cyberspace to the blogosphere. The carrier of the identity is no longer simply a participant in the virtual world, but becomes a generator of it. Bloggers, with their massive creativity, have transformed cyberspace and assigned a new qualifier to the cybernaut: "author". The owner of a VID now has to take care of a new side of his profile, his "*digital reputation*", a ranking derived from the credibility and truthfulness of his utterances as much as by hits on his blog. The VID does no longer just exist in a game or in a virtual community since its visibility becomes enormously magnified by all the connecting and disseminating devices populating the Web.

DIGITAL IDENTITY

When we relate virtual identity with digital technologies we come to the notion of *digital identity*. According to the PRIME nomenclature:

«Digital identity.

Digital identity denotes attribution of properties to a person, which are immediately operationally accessible by technical means […] can be a simple e-mail address in a news group or a mailing list. Its owner will attain a certain reputation. […] Digital identity should denote all those personally related data that can be stored and automatically interlinked by a computer-based application. » (Pfizmann et al., 2006, pp. 24-25)

In the digital online world, the original meaning of "identity" (univocity of a person in a world of "others") is lost, identity undergoes *multiplication* and *fragmentation*. As "citizens" of this world, each of us must manage our registration with a multiplicity of "e-services", corresponding to as many personal data sets, stored somewhere. It is estimated that an active user on the Web accumulates more than 20 passwords and that the citizen of a modern country has personal data on more that 500 files.

Digital Identity Management

The online world has given rise to a completely new problem that requires a completely new set of solutions. It is necessary to look at Virtual Identity from a "procedural" point of view (Beslay & Bogdanowicz, 2001, p. 2). There is an astounding amount of delinquency against identity, acting in various forms: spam, identity theft, impostor sites, spoofing, phishing. A new area of high concern and debate but also of intense research has appeared inside the whole ICT community, called (digital) *identity management* (IdM). A popular definition by the Burton Group (www.burtongroup.com) is:

«Identity management is the set of business processes, and a supporting infrastructure, for the creation, maintenance, and use of digital identities. »

IdM comprises three distinct logical steps:

- **Identification:** Which elements (identifiers) the user presents to access the service (e.g., username);
- **Authentication:** A way in which the system verifies that the representation of identity offered by the user is valid (the user is what the user claims to be, e.g., by providing a password);
- **Authorization:** Verifying the user's credentials, as to what the user is allowed or not allowed to do.

Along each of these layers, technology is advancing with respect to what has been called the "Stone Age" of IdM, the username/password approach, which has been precisely the cause of the uncountable proliferation of identities and of the almost total loss of protection.

Among the key approaches being developed there is the *Federated IdM* approach, which is also the direction of proposed standards, such as the Liberty Alliance (Liberty Alliance, 2005). At the basis of the concept of Federated Identity there is an established Web of trust between service providers that allows the user to be accepted without the need to repeat a new login every time. This type of solutions (called Single Signon) not only greatly facilitates the user but also minimizes sensitive data and provides enhanced security. Implementations begin to appear, such as *SXIP* and *LID* (LID, 2007; SXIP, 2007), but this is still a very young industry, facing many unknowns. A big question looming in the background is what governments will do, often controversially invoked to act as the definitive "authoritative source" for digital identity issuance.

VIRTUAL RESIDENCE

"*Virtual residence*" is a powerful new concept due to the Cybersecurity Team of the previously cited IPTS institution (VR Project, 2004). Different from other descriptive or explicative concepts concerning identity in the virtual dimension, it is a prescriptive one. It is proposed as a model of thought, a guideline to systematically face the challenges concerning security and identity when living in the digital age. Its promulgation is found in a remarkable document, "*Digital Territories: Bubbles*", considered a fundamental point of reference (Beslay & Hakala, 2005). Therein an important vision is introduced, the image of the "*bubble*", a dynamic personal infosphere, the virtual membrane that identifies the sphere of the individual, while moving across different places and activities (Figure 2).

The management and the safeguard of identity in networked worlds is a main concern at the heart of the *AmI vision* (ambient intelligent vision) cultivated at a strategic level by Europe and supported by the investments of EU's ongoing Research Framework Programs. The *Ambient Intelligence Space* is the future habitat of the information society's citizen. A key document issued by the European Commission so describes it:

«Ambient Intelligence Space is the collection of technologies, infrastructures, applications and services across different AmI environments. Examples of future AmI environments are the home, the car, the school, the neighbourhood, the city, etc. […] The AmI Space is composed of collaborative (location or social based) sub-spaces, of devices (including sensor and actuator systems), services (including their interfaces) and the connecting networks» (IPTS, 2003, p. 72)

There is a reason for the need of new guidelines for social behavior. This space, simultaneously technical and social, is quite an unknown. Laws, values, notions and conventions, to which we are accustomed in the physical world, fail and a replacement is missing. In front of this situation Virtual Residence is a clarifying concept. It consists of three elements that form the space where the real/virtual identity of the individual has a meaning and a role:

- The future ambient intelligent and connected home (computing embedded in everyday objects connected via domestic infrastructures);
- The online lives of people, families, and households and their virtual representation, and
- Mobility and interoperability between different AmI environments (Kameas, 2006).

The key concept and vision introduced by the IPTS researchers is the "bubble", the pictorial representation of the "digital territory" (DT), a technical concept supporting the one of virtual residence. DT is a notion of space and borders, referred to its owner, as depicted in Figure 2. According to this model, it will be possible to filter or reject the transit of data, to deny access according to security and privacy criteria and build defenses against malicious attempts of contact.

The virtual residence is then a special case of a digital territory, as we project the physical residence of the "intelligent home" in the online world. What this bubble will contain and protect is not only the registry data of the dwellers, but the whole mass of digital data surrounding them, like PC files, work documents, schedules, health information, family archives.

The objective of this type of research is that the emerging PETs (privacy enhancing technologies) may adopt these concepts as key references and citizens may become more aware of their digital identities.

Figure 2. Digital territories and bubbles in the AmI Space: A scheme for interaction and protection

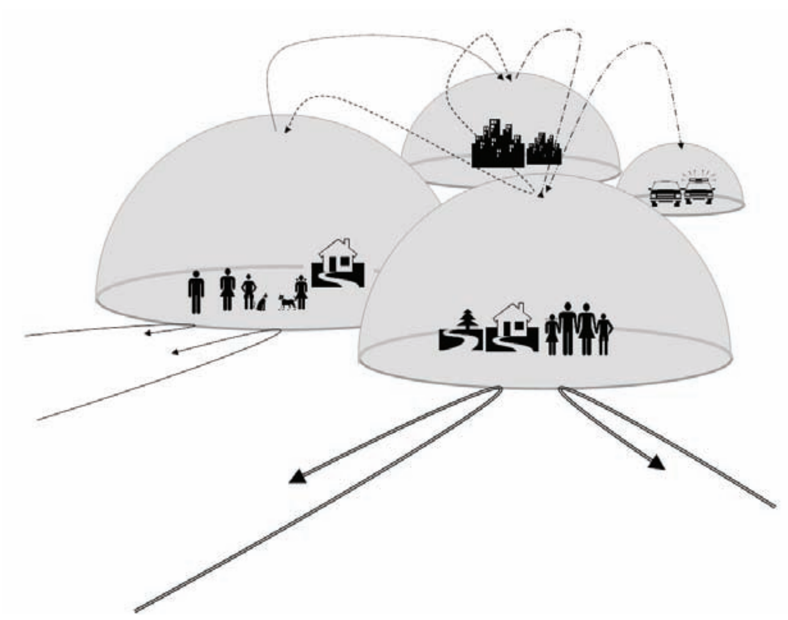


Figure 3. In Second Life you can even do skydiving (Source: Courtesy of secondlife.com - © 2006, Linden Research, Inc. All Rights Reserved)

ULTRAWORLDS, A NEW ERA

We are fully immersed in a changing landscape, therefore it is difficult to separate stable trends from volatile ones. Already a new phase has been announced, giving a strong twist to the concept of identity in the virtual world. Advanced visualization technologies, namely 3D, extremely fast telecommunication channels and sharp software tools have become the drivers of the so-called immersive worlds or *MMORPGs*. The now famous *Second Life* (http://secondlife.com/), where real and virtual currencies and habitats collide is a perfect example of "a new way of being". Inside Second Life the perfection of the avatars well reflects the richness of actions and behaviors that a "3D virtual identity" may express in these kinds of worlds (Figure 3).

This form of extreme interaction cannot be dismissed as just a world of wizards and technologically expert people. The software technology behind immersive worlds is making great strides outside the gaming arena. An example is *Open Croquet*, probably the most innovative, open-ended software technology of our times. It is "for the creation and large-scale distributed deployment of multiuser virtual 3D applications and metaverses that are (1) persistent (2) deeply collaborative, (3) interconnected and (4) interoperable" (http://www.opencroquet.org/.). There is no doubt that the concepts we have discussed, virtual identity, digital identity and virtual residence will undergo yet more transformations as these worlds emerge and generate knowledge experiences that were unthinkable just a short while ago. It is indeed a new and surprisingly fast changing era.

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KEYWORDS

Federated Identity Management: An approach by which a set of service providers, explicitly linked by a reciprocal trust relation (a *circle of trust*), agree to support a scheme where the user does not have to establish his/her identity at every attempt to access a different service, but does so just once (also known as SSO, *Single Sign-On*). In the "circle", providers have two profiles, the service provider and the identity provider. The service provider will accept as valid identifiers those of a user, which has been previously authenticated by an identity provider, so that the user will transparently access the service without having to do an authentication step.

Identity: An elusive concept, best explained in the cited PRIME dictionary:

«Identity can be explained as an exclusive perception of life, integration into a social group, and continuity, which is bound to a body and shaped by society. This concept of identity distinguishes between "I" and "Me" […]: "I" is the instance that is accessible only by the individual self, perceived as an instance of liberty and initiative. "Me" is supposed to stand for the social attributes, defining a human identity that is accessible by communications and that is an inner instance of control and consistency. » (Pfizmann et al., 2006, p. 22)

Metaverse: A term out of the book "Snow Crash" by Neal Stevenson, it has been widely adopted to describe virtual online words. These new spaces have been existing mainly as gaming places, but a new generation is expected based on new technologies, such as the ones embedded in *Croquet* (http://www.opencroquet.org/). Open Croquet is a recent, revolutionary open source platform conceived to support 3D immersive, highly visual collaboration spaces. It is a joint software development between the University of Minnesota at Madison and VPRI (ViewPoints Research Institute) in California. The people working at this project are an exceptional group of inventors belonging to the ICT world, among which there is Alan Kay, inventor of the Smalltalk language, ancestor of all windowing OS's, leading at VPRI; Doug Englebart (hypertext); Marvin Minsky, Nicholas Negroponte (pioneers at MIT), Seymour Papert (Logo, computers for learning); David Reed (several Internet laws). The tool is usable for building boundless applications, ranging from simulations to synchronous massive multiuser environments.

Virtual Communities: For Howard Rheingold (1993), *«Virtual communities are* social aggregations *that emerge from the Net when enough people carry on those public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace. »* They have been extensively investigated (Wenger, McDermott, & Snyder, 2002) because of the many possible roles of the participants, the sophisticated technological platforms they may adopt and the variety of shapes they take (Trentin, 2004).

Virtual Reality and Virtual Environments in Education

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INTRODUCTION

Virtual reality (2007), or VR, is defined in the *Encyclopædia Britannica* as:

the use of computer modeling and simulation that enables a person to interact with an artificial three-dimensional (3D) visual or other sensory environment. VR applications immerse the user in a computer-generated environment that simulates reality through the use of interactive devices, which send and receive information and are worn as goggles, headsets, gloves, or body suits.

Jaron Lanier, virtual reality pioneer, claims to have popularized this technology in the early 1980s, but the origin of the term "virtual reality" is uncertain. It has been credited to *The Judas Mandala*, a 1982 novel written by Damien Broderick, where the context of use is somewhat different from that defined above. One of the first applications of this technology was in the military area, especially in 3D interactive computer graphics and flight simulators. Another area of application for VR systems has always been training for real-life activities. A virtual reality system has the following three primary requirements: immersion (which permits to the user the physical involvement, capturing exclusive visual attention, and responding to three-dimensional input. For example, through a data glove, head-tracker, 3D mouse, or fully instrumented body suit); interaction (through the three-dimensional control device to "navigate" in the virtual environment); and visual realism (which is a representation of the virtual world using computer graphics techniques) (Rosemblum & Cross, 1997). VR is usually classified according to its methods of display. We have: immersive VR and non-immersive VR. Immersive VR involves a high degree of interactivity and high cost peripheral devices, for example, the head mounted displays. This kind of VR can generate the "avatar" or "virtual body" (user's representation of himself or herself, whether in the form of a three-dimensional model). Non-immersive VR, often called "desktop VR," is in the form of a windows into a virtual world displayed on a computer's monitor (Earnshaw, Chilton, & Palmer, 1997). This article describes the use of low cost non-immersive virtual reality integrated in teaching path in a faculty of architecture, where this technology can help to define new paradigm in the architectural design.

BACKGROUND

Many researchers affirm that virtual reality offers benefits that can support education (Antonietti, Imperio, Rasi, & Sacco, 2001; Byrne, 1996; Gerval, Popovici, & Tisseau, 2003; Mantovani, 2001; Pantelidis, 1995; Sala & Sala, 2005; Shin, 2004; Stangel & Pantelidis, 1997; Winn, 1993; Youngblut, 1998). VR is also a good medium to apply the philosophy of constructivism and for making abstract concepts concrete, for example, to emphasize the physics' laws or chemistry's principles (Byrne, 1996; Johnstone, 1991; Jonassen, 1994; Zoller, 1990).

At the Human Interface Technology Lab (HITLab), a part of the Washington Technology Center (University of Washington in Seattle), some pilot studies have been performed to examine virtual reality's potential in the field of training and education. For example, the Pacific Science Center Studies used 10 to 15 year old students who were attending a week-long summer day camp. Some of these students were novice computer users, while others had a good computer knowledge. In groups of 10 students, they brainstormed virtual world creations. In subgroups, composed by 2 or 3 students, they have created virtual objects for their world using specifications, for example, how the objects should be placed and moved in the virtual world (Youngblut, 1998).

Using the constructivist approach, Byrne (1996) created a virtual environment to stimulate the students to learn the chemistry by exploring and interacting with a virtual world. Instead of staying in a classroom and passively viewing images of the atomic structures, the students can place electrons in the atoms and they can see the atomic orbital appear as the electron buzzes.

Pantelidis and Auld (Virtual Reality and Education Laboratory (VREL), East Carolina University) used a software package called Virtus® VR on a group of primary school children. The aim of this activity was to promote children's abilities to conceptualize in three-dimensional space and to have fun and provide a sense of achievement while doing so. The children created the interior of a room or building, with walls, doors, windows, and furniture designed and edited and then placed in the appropriate part of the screen-based construction. Keyboard-controlled movement though the three-dimensional representation is possible at any time (Stangel & Pantelidis, 1997).

Gerval, Popovici, Ramdani, El Kalai, Boskoff, and Tisseau (2002) created a distributed virtual environment for children. The project, named EVE (Environnement Virtuels pour Enfants), involved nine partners (universities, primary schools, and small and medium-sized enterprises) for three different countries: France, Morocco, and Romania. On a pedagogical perspective, the main goal of the EVE project is teamwork. In fact, children from different countries are involved in cooperative work. They have to achieve a common task together, hoping that this will encourage respect in a multicultural framework. On a technical perspective, this project implements distributed virtual reality technologies. From both points of view, EVE is a NICE-like environment, being narrative, immersive, constructionist, and collaborative. The EVE application has been developed in order to help the primary school children learn French and especially the reading. The target of the project is twofold:

- To realize new cooperative working environment
- To create new products development such as pedagogical software for primary school children

Shin (2004) presented the educational possibilities of the Web-based virtual experiment environment in science education. He developed a virtual experiment environment supporting students to learn scientific phenomena and concepts focusing on earthquake waves, radiation balance, movements of sea water, solar system, and earth's crust structure in the science field of middle school. These virtual experiments have been designed to be compatible to the learner levels through level analysis in the following cycle model: regular, advanced, and remedial course. The virtual experiments have been evaluated for six months using 701 middle school students, and 74.6% of students gave a positive response on the use of VR in the science experiments.

HOW TO APPLY VR IN EDUCATIONAL ENVIRONMENTS

Pantelidis (1997) presented a model for choosing where to apply VR in any one course. She proposes a model, based on the work of Leslie J. Briggs and Robert Gagnè (Gagnè & Briggs, 1979), which comprises the following 11 phases:

1. Define the objectives for specific course.
2. Mark the objectives that could use a simulation as a measurement or means.
3. Each of the marked objectives is examined: first to determine if it could use a computer-generated simulation for attainment or measurement, then to determine if it could use a three-dimensional (3D), interactive simulation.
4. Choose for each selected objective the level of realism required on a scale from very symbolic to very real.
5. Decide the type of interaction needed on a scale from no immersion into the 3D environment (for example, desktop VR) to full immersion (for example, using head-mounted display, data gloves, and so forth).
6. Establish the type of sensory output from the virtual world or environment desired, for example, haptic (tactile or feeling), 3D sound, or visual only.
7. Choose VR software and hardware/equipment.
8. Design and build the virtual environment (VE). The virtual environment may be built by the teacher, the students, or both.
9. Evaluate the resulting virtual environment using a pilot or experimental group of students.

10. Modify the virtual environment using the results of the evaluation.
11. The modification continues until the VE is shown to successfully measure or aid in attainment of the objective.

VIRTUAL REALITY IN EDUCATION: THE CASE OF A FACULTY OF ARCHITECTURE

At this point, it is important to understand the reasons that bring to use VR in a faculty of architecture. Therefore, it is logical to do some considerations. In architectural design, the computer is a medium that can be used in different ways, for example, as a tool to conceive new shapes, using Non-Uniform Rational B-Spline (NURBS) and hypersurfaces. The computer is entering in the creative process and it acquires a sense in the architectural design process (this approach is used by the famous architect Peter Eisenman). The evolution of IT introduces the concept of virtual architecture that has only recently emerged with the ability of computer-imaging technology to accurately simulate three-dimensional reality. In an age dominated by the computer and by the electronic media, it is becoming increasingly clear that the perception of space is also undergoing a profound transformation. The traditional architectural space is changing; buildings are being rendered transparent, fleeting and intangible, enhanced by virtual potential.

In agreement to these considerations, in the course named "New Media for Architecture" (3 credits, Academy of Architecture-Mendrisio, University of Lugano, Switzerland), VR technology has been integrated in the teaching path since 2004. Using Pantelidis' model (1997), we have established the different phases which suggest how to insert the virtual reality inside our course (from the definition of the objectives for the course to the creation of virtual objects in low cost non-immersive VR technology). The introduction of virtual reality in the teaching path has been organized in two parts. In the first part, the teacher introduces and explains to the students, using VR, important topological objects (for example, the Klein's bottle, the Moebius strips), the hypersurfaces and their use in architecture. For example, describing the "Moebius House," conceived by Ben Van Berkel and Caroline Bos, with a virtual tour inside it. Virtual objects and virtual buildings have been realized by the teacher using virtual reality modeling language (VRML), and they can be manipulated with the mouse and the keyboard.

In the second part, students familiarized with VR in the first part of the course used the VR technology as project tools, realizing virtual buildings and virtual worlds. They also integrated the technology as a tool to communicate their architectural projects. Students also created VR low cost objects, for example, trees using simple fractal algorithms based on iterative and recursive processes. These teaching experiences emphasize some positive aspects, for example, the strong impact that VR technology has on students. This impact helps in the comprehension of the complex topological and geometrical shapes. The use of VR in teaching path can also help students to use this technology in their future working activities.

Henderson (1999) notes that: "Young designers trained on graphics software are developing a new visual culture tied to computer-graphics practise, that will influence the way they see and will be different from the visual culture of the paper world" (Henderson, 1999, p. 57). Architects who have grown up with digital media and virtual reality will be expert users of interactive, spatial, real-time environments (Prestinenza Puglisi, 1999; Whyte, 2002).

FUTURE TRENDS

The connection between the Internet and virtual reality will have great potential for educational and learning environments. A revolution is already underway outside of education with the Web as the primary information and retrieval tool, and the virtual reality as a medium to reconstruct and to interact with virtual objects. One of the main aims of VR is to create virtual worlds and virtual environments in which humans can interact together. The problem of the interaction with other users will be raised in the near future. The realism presumably will play a major role in the program's success and likely will prove positive in future endeavors.

How to Create the Virtual Worlds

Some virtual worlds will be oriented certainly to the educational field and others for training, research, or fun. Architects will potentially help to make the virtual world a pleasant and stimulating place to work and live in with a good quality of life. This will require people who understand the psychological effects of the spaces generated by the computer on people inside them, and the architects have to prepare themselves to this new work opportunity.

For architectural education, virtual reality will become the place to go to do things that you could not normally do in architect-designed buildings. Spaces created with fractal and non-Euclidean geometry will exist, and they could be modified using soft-computing techniques. In the near future, we will introduce immersive VR in our teaching environment, and we will try to realize virtual world, but one problem at the moment is the cost to realize it.

CONCLUSION

This article illustrates how to integrate VR technology in a teaching path in a faculty of architecture. Several research studies around the world demonstrated the potential of virtual reality systems as visualization tools, and, as technology continues to improve, VR systems will become pervasive instrumentation in the future. The use of VR in education represents a phase in the evolution of teaching and training methods. Important examples the uses of virtual reality include:

- Learning in context impossible or difficult to experience in real life (Byrne, 1996; Youngblut, 1998)
- Foreign language acquisition through immersion in a virtual environment where the language can be heard and its meaning understood (Boudreau & Okada, 1998)
- Engineering training in virtual laboratories providing access to remote in hazardous environments (Antonietti et al., 2001)

Virtual reality, connected to the Internet and the World Wide Web, can create cyberspaces and virtual communities that contribute to realize active learning environments and more incisive training processes. VR is invaluable to modern architects, as it allows them to simulate most scenarios that they will encounter during the design, construction, and eventually the life of the structure they are attempting to build. Virtual reality allows architects to essentially create their structures and test them without wasting any of the resources necessary to complete the structure in reality. In the future, architects as designers of virtual worlds will be required to make these environments interesting, rich, and engaging places. Therefore, it is important to prepare correct training on the use of VR in the faculties of architecture.

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KEY TERMS

Avatar: Derived from the Sanscrit for the incarnation of Godhead. In virtual environments, an avatar is the "body" that a user "wears" in a virtual community, an animated, articulated representation of a human which represents the user.

Data Glove: A glove wired with "biosensors" to detect hand and finger motions.

Flight Simulator: A mechanical or electronic system for training airplane and spacecraft pilots by simulating flight conditions. The purpose of simulation is to thoroughly familiarize students with the vehicle concerned before they undergo expensive and dangerous actual flight training.

Fractal Algorithms: Algorithms used in creating computer-generated images. Using either an iterative or recursive process, simple geometric shapes are divided and replaced by smaller versions of themselves.

Haptic Feedback: It is the sense of touch at the skin and force feedback information from muscles and joints.

Head-Mounted Display (HMD): A graphical display device, such as a pair of tiny LCD screens worn like goggles. Often combined in a single helmet with position tracking sensors and earphones for 3D sound.

Immersion: When several of a user's senses are isolated from the real world and fed information (images and sound) coming from a computer.

Non-Uniform Rational B-Spline (NURBS): A mathematical model commonly used in computer graphics for generating and representing curves and surfaces.

Soft-Computing: A discipline situated at the confluence of distinct methodologies: fuzzy logic, neural network, and probabilistic reasoning, the latter including evolutionary algorithms, chaos theory, belief networks and, though only partially, learning theory. Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, and partial truth.

Tactile Feedback: A glove that uses air pressure or vibration to apply force to the wearer's hand, giving a realistic perception when virtual objects are touch.

Virtual Reality Modeling Language (VRML): A language that specifies the parameters to create virtual worlds networked together via the Internet and accessed via the World Wide Web hyperlinks. The aim of VRML is to bring to the Internet the advantages of 3D spaces, known in VRML as worlds whether they compromise environments or single objects.

Web-Based Course Management Systems (WCMS) Acceptance with College Students in Estonia

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INTRODUCTION

Increasingly, higher education institutions worldwide are adopting information and communication technologies (ICTs) to enhance pedagogy (Ifinedo, 2006; Lee, Cho, Gay, Davidson, & Ingraffea, 2003; Leidner & Jarvenpaa, 1993). Web-based course management systems (WCMS), such as *WebCT* and *Learning Space*, are among the notable ICTs diffusing in higher learning environments globally (Ifinedo, 2006; Tavangarian, Leypold, Nölting, Röser, & Voigt, 2004). WCMS are sometimes referred to as course management systems (CMSs). An instructor using a CMS can place course materials online, communicate with students, track their progress, and conduct online tests, quizzes, and so forth. Sometimes, CMSs are confused with another group of learning technology known as learning management systems (LMSs). Carliner (2005) provides a clear distinction between the two technologies; he notes that CMSs are used in the management of asynchronous educational environments (AEEs) whereas LMSs are basically registrars that perform various enrollment and registration tasks electronically. Examples of LMSs include *Saba*, *NetDimensions EKP*, and *SumTotal*. Both technologies are essential for an effective virtual learning environment (VLE) (Carliner, 2005; Tavangarian et al., 2004). We focus solely on WCMSs in this article in the bid to not generalize the two technologies.

The objective of this article is to present the results of a study that investigates the acceptance of WCMS among college students in Estonia. The country is an emerging economy in the Baltic region of Europe. Estonia has made remarkable progress with respect to the use of ICT products in enhancing education at all levels (The Tiger Leap Foundation, 1997). Recently, Estonia joined forces with a pan-European e-learning project called the UNIVe (Estonian eUniversity, 2004; Ifinedo, 2005). Among other goals, the project aims at "increasing the availability of quality education for students and other people willing to learn …and, educating lecturers of universities to compile and practice quality and efficient e-courses" (Ifinedo, 2006). In brief, the UNIVe project aspires to improve VLEs for the participating countries. WebCT is among the VLE tools being used by college students in Estonia. In this respect, this study will increase our understanding regarding the acceptance of such technologies in the region. The research is important for three reasons: (1) first, to provide empirical information about the acceptance of WCMS among Estonian college students, (2) to complement a recent study in Estonia in which the experiences of college teachers on WCMS was investigated, and (3) to answer calls being made for ICT studies to be extended to the other regions of the world, including Eastern Europe (see Ifinedo, 2006). Furthermore, this study draws from the technology acceptance model (TAM); for a theory to be considered valid, its veracity across a wide range of contexts needs to be established. Importantly, the findings of the study will be beneficial to administrators, instructors, and other entities involved in various e-learning projects in Estonia and comparable countries in the region.

LITERATURE REVIEW

Among the most widely used theoretical frameworks for assessing the adoption or acceptance of technologies in the literature is the TAM, which was developed by Davis (1989). The model is comprised of three constructs (Figure 1). In brief, the TAM proposes that users' acceptance of new information systems (ISs) can be predicted by the users' perceptions of the ease of use and usefulness of the IS (Davis, 1989). The p*erceived ease of use* construct in the TAM describes "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). The second construct is the *perceived* *usefulness* which describes the user's perceptions of the expected benefits derived from using a particular IS system (Davis, 1989). *Usage* is the dependent variable in the TAM, and it is "theorized to be influenced by perceived usefulness and perceived ease of use" (p. 320). In general, IS researchers have confirmed the relationships in the TAM (see Straub, Limayem, & Karahanna, 1995).

Researchers (e.g., Brown, 2002; Lee et al., 2003; Limayem, Cheung, & Chan, 2003; Pan, Siva, & Brophy, 2003) have studied the adoption and acceptance of WCMS in college environments. Brown (2002) studied the acceptance of *WebCT* among college students in a developing country, The Republic of South Africa (RSA). He found that perceived ease of use is strongly related to usage and perceived usefulness. Limayem et al. (2003) found support among the constructs used to investigate the adoption (and continuance intention) of WCMS among students in Hong Kong, a developed economy. Lee et al. (2003) reported strong relationships between perceived ease of use and perceived usefulness as did Brown (2002). However, other researchers have reported equivocal results regarding the suitability and relevance of the TAM for WCMS in higher learning contexts. For example, Pan et al. (2003) concluded that the TAM may in fact not be applicable to higher educational settings following the lack of support among the relationships for the constructs in their study. In the same vein, other findings in the IS literature examining the relationships in the TAM framework have indicated mixed results as well (Gefen & Straub, 2000). Nevertheless, the TAM remains the most widely used framework for studying technology adoption and acceptance by IS researchers.

THE RESEARCH FRAMEWORK AND HYPOTHESES

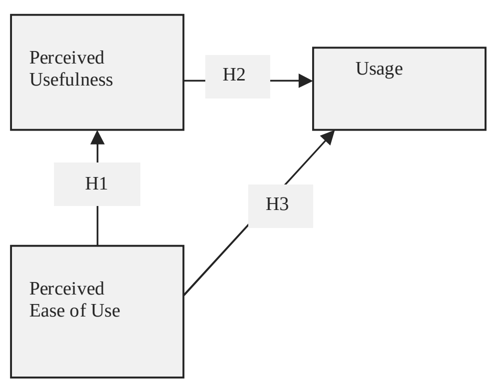
Figure 1 illustrates the TAM as well as a research model used for the study. The arrows in Figure 1 indicate the directions of the hypotheses (H1–H3) that are discussed in-depth below.

Perceived ease of use and perceived usefulness have been noted as important predictors of information systems (IS) usage (Adams, Nelson, & Todd, 1992; Davis, 1989; Igbaria, Zinatelli, Cragg, & Cavaye, 1997; Straub et al., 1995). Studies have shown that perceived usefulness and perceived ease of use are good predictors of usage (e.g., Adams et al., 1992, Igbaria et al., 1997; Straub et al., 1995). As previously noted, others have raised doubts as to the veracity of the framework or model for VLE tools in higher educational settings (Pan et al., 2003).

Gefen and Straub (2000) suggested that perhaps some aspects of the TAM may be relevant for IS acceptance in the developed West. They listed 42 studies using the TAM and noted that 25 of these studies did not show perceived ease of use to be a significant predictor; the others showed mixed results and only nine studies seemed to uphold the view that perceived ease of use is a predictor of usage. At a general level, Gefen and Straub suggested that the perceived usefulness construct tends to support the TAM consistently. Similarly, other researchers (e.g., Anandarajan, Igbaria, & Anakwe, 2002; Brown, 2002) using the TAM to research IS acceptance in developing countries underscored the pertinence of relevance of regional contextual influences. For example, Anandarajan et al. (2002) and Brown (2002)—researching *WebCT* acceptance among students—found that perceived usefulness is not a significant predictor of usage, which is contrary to the view in Gefen and Straub. This information indirectly strengthens the observations in Gefen and Straub highlighting the role of contextual considerations. In this regard, results for the acceptance of WCMS in a developing country like RSA indicated that a strong relationship exists between perceived ease of use and usage.

Despite its size, Estonia leads Eastern Europe with regard to the adoption and use of ICT products for socio-economic development. With regard to the Internet diffusion per capita, Estonia is among the world's lead-

Figure 1. The technology acceptance model



ers (WEF, 2004). Estonian leadership in ICT products' use and diffusion has benefited various Web-based and e-learning initiatives in the country (Estonian eUniversity, 2004; The Tiger Leap Foundation, 1997). Given these favorable conditions, it would be reasonable to conjecture that use of, and experience with, Web-based technologies, including WCMS, among students in the country will be positive. Following the foregoing discussion, we propose a set of hypotheses:

H1: Perceived ease of use of WCMS among Estonian college students will have a positive effect on perceived usefulness of WebCT.

H2: Perceived usefulness of WCMS among Estonian college students will have a positive effect on usage of WebCT.

H3: Perceived ease of use of WCMS among Estonian college students will have a positive effect on usage of WebCT.

RESEARCH METHODOLOGY

Method and Research Constructs

This exploratory study used a convenient sample of 72 students. The participants came from four tertiary institutions in Estonia, that is, The Estonian Business School, Tallinn University of Technology, Tartu University, and Estonian IT College. The study used judgmental sampling (Neuman, 1997), an approach that permits the researchers to self-select research elements with experience or expertise in the research theme. The author self-administered a two-page questionnaire to students with *WebCT* experience. The students were classified into two groups. Thirty students in the information technology (IT) and engineering disciplines were labeled "IT savvy" and those from the social sciences and the arts as "non-IT savvy." (See Table 1 for their mean scores for the TAM constructs.) Importantly, a *one-way ANOVA* test between the two groups of students indicates little or no statistical differences between the two groups. (Recall the purpose of the study is to elicit views of students that have used *WebCT*; thus, we did not consider the views of "non-adopting" students.)

The questionnaire included validated measures from the relevant literature. It contained multiple indicators for each of the constructs (see Appendix). Three and four items were used to measure *perceived usefulness* (PUS) and *perceived ease of use* (PEOU), respectively. The seven items were taken from Davis (1989) and Brown (2002). The *usage* (USG) scale consists of two items from Igbaria (1990). The measurements were operationalized using a Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree) except for *WebCT* usage measures which used five and six options. SPSS 10.0 and PLS Graph 3.0 were used for data analysis. The students' demographic profile and the diversity in *WebCT* use are shown in Table 2.

Data Analysis

The PLS (partial least squares) procedure is used to assess the casual model. The approach is suitable for studies with small-sized samples (Chin, 1998) such as this one. PLS recognizes two components of a casual model: the measurement model and the structural model. The measurement model consists of relationships among the factors of interest (i.e., the observed variables) and the measures underlying each construct; it demonstrates the construct validity of the research instrument (i.e., how well the instrument measures what it purports to measure). The two main dimensions are the convergent validity and discriminant validity. First, convergent validity (composite reliability) assesses the extent to which items on a scale are theoretically related. Chin (1998) recommends items with loadings of greater than 0.70. Second, discriminant validity checks the extent to which items measure a construct. The square root of the average variance extracted (AVE) for each construct is used to check this measure. Fornell and Larcker (1981) recommend values higher than 0.50. In the structural model, this measure gives information as to how well the theoretical model predicts the hypothesized paths or relationships. PLS software provides the squared multiple correlations (R^2) for each endogenous construct in the model and the path coefficients. The R^2 indicates the percentage of a construct's variance in the model while the path coefficients indicate the strengths of relationships between constructs (Chin, 1998).

Table 1. The breakdown of the respondents

Measures and constructs	IT savvy students (mean)	Non-IT savvy students (mean)	All students (mean)
Perceived usefulness (PUS)	4.09	3.28	3.62
Perceived ease of use (PEOU)	5.96	4.65	5.12
Usage (time spent) (USG1)	3.33	3.40	3.37
Usage (frequency) (USG2)	3.90	4.29	4.13

Table 2. Demographic profile of respondents

		Number	Percent
Gender	Male	32	44.4
	Female	40	55.6
Age	Less than 25 years	63	87.5
	26-39 years	9	12.5
Education (level)	Year 1	13	18.1
	Year 2	22	30.6
	Year 3	13	18.1
	Year 4	24	33.3
Study program (Department)	Business / Economics	36	50
	Information Technology	16	22.2
	Mechanical Engineering	9	12.5
	Philosophy	6	8.3
	Electrical Engineering	5	6.9
Years of experience with the Internet	1-2 yrs	1	1.4
	2-3	5	6.9
	3-4	9	12.5
	4-5	23	31.9
	more than 5 yrs	34	42.7
Diversity of WebCT use		Mean	Standard deviation
	Web browsing	5.13	1.79
	downloading	5.00	1.50
	e-mail	5.61	1.57
	chat room	5.53	1.99
	discussion lists	3.32	1.52
	Each task was anchored on a Likert scale ranging from 1 (Never use it) to 7 (Use it a great extent).		

Table 3. Psychometric properties of constructs

Construct	Item	Loading	t-value	Composite reliability
Perceived ease of use (AVE = 0.732)	PEOU1	0.8037	11.2561	0.916
	PEOU2	0.8640	18.9045	
	PEOU3	0.9008	42.8258	
	PEOU4	0.8519	22.8740	
Perceived usefulness (AVE = 0.815)	PUS1	0.9004	30.0409	0.930
	PUS2	0.9352	57.0995	
	PUS3	0.8722	24.2192	
Usage (AVE = 0.914)	USG1	0.9513	52.2206	0.955
	USG2	0.9611	82.7979	

Table 4. Correlations of latent constructs

	AVE	PUS	PEOU	USG
PUS	0.815	**0.903**		
PEOU	0.732	0.650	**0.856**	
USG	0.914	0.503	0.714	**0.956**

Assessing the Measurement Model

Table 3 shows the results of the measurement model. The composite reliability values were consistently above 0.9, which exceeds the recommended values by Chin (1998). The items loadings meet Chin's (1998) guideline of between 0.60 and 0.70. Each of the construct's AVEs exceeds the 0.5 guideline as suggested by Fornell and Larcker (1981). Table 4 shows the AVEs, intercorrelations among the constructs, and the square root of AVE (in bold text). No correlations were equal to or greater than the squared root of AVE in the leading diagonal. This suggests that our measures are distinct and unidimensional. In brief, the convergent and discriminant validity in this study is psychometrically adequate.

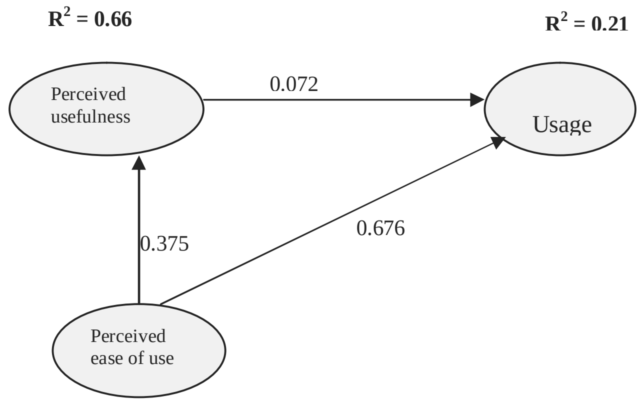
Assessing the Structural Model

As noted above, the structural model is concerned with the explanatory power of variables. Figure 2 shows the path's coefficients and the size of the R^2 values. The values are generated by PLS Graph 3.0. The test of significance of all the paths was done using the bootstrap resampling procedure with 200 resamples. It can be seen that perceived ease of use has a strong effect on perceived usefulness with a path coefficient of 0.375 and accounts for 66% in the variation of perceived usefulness. The perceived ease of use construct has a significant effect on usage of *WebCT* (path coefficient = 0.676). Inconsistent with our hypothesis (H2), perceived usefulness did not have a significant effect on *WebCT* usage (i.e., the path coefficient is 0.072). Together, perceived ease of use and perceived usefulness explained 21% of the variance in the usage construct.

DISCUSSION AND CONCLUSION

This study investigates the acceptance of WCMS by college students in Estonia, which is an emerging

Figure 2. The results of PLS Graph 3.0 analysis



economy in Eastern Europe. The study found support for two of the paths (i.e., hypotheses) in the TAM. To our knowledge, this study is among the first to investigate this theme in the Baltic region. The study found support for relationships between perceived ease of use and usage and perceived usefulness, but the data did not support the relationship between perceived usefulness and usage.

The empirical evidence from this study can make both practical and theoretical contributions. Practically, the findings suggest that college students and other entities using WCMS and related technologies use them more when the use of such tools is perceived to be less difficult to use. It is not sufficient to expect that the perceived usefulness of WCMS and related VLE tools will lead to an increase in their use (and success). This finding is useful for e-learning and Web-based learning projects administrators in Estonia and similar countries that may be looking for empiric information that could enable them to maximize their returns on investment in VLE and AEE technologies. Theoretically, the results in this study add to the debate regarding the results obtainable in the TAM studies in general (Gefen & Straub, 2000) and for WCMS acceptance in higher education settings in particular (Pan et al., 2003). As was discussed, Gefen and Straub (2000) suggested that some aspects of the TAM may be more important for IS acceptance in richer nations. Anandarajan et al. (2002) and Brown (2002) provided evidence for developing countries. In this study, we enriched insight with evidence from an emerging economy country. The data analysis and conclusions lend support to the observations with regard to the results in the TAM studies in the developing and emerging countries; that is, perceived usefulness and usage are less of a predictor in the TAM for IS acceptance in these contexts. With this contribution, the body of knowledge in the IS field is enriched and new insights could emerge. For example, researchers could also investigate why such differences exist.

There are limitations in this study. The research is exploratory; as such, a convenient sample size of 72 may be limiting. The selected subjects may not be representative of all college students in Estonia (or the region). The measurement of *WebCT* usage was self-reported; and this might limit insight. This study is a cross-sectional study; a longitudinal study may be enlightening. In order to improve upon the generalizability of this study's findings, future studies could increase the sample size as well make an effort to incorporate other relevant variables such as age, peer pressure, and facilitating conditions into the research model.

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KEY TERMS

Asynchronous Educational Environment (AEE): This is a learning–teaching environment in which there is no timing requirement. Students can access course material any time from anywhere.

Emerging Economy: This term has differing interpretations; however, for the purposes of this study, we used it to refer an economy-type whose socio-economic indicators (e.g., poverty and technological levels) are better than those of developing countries (e.g., Nigeria and Burma), but lower in comparison to richer countries (e.g., Italy and Canada). Examples of emerging economy countries include Estonia and Hungary.

Learning Management Systems (LMS): These are tools that primarily act as electronic registrars and allow the monitoring of various enrollment and related tasks in a virtual learning environment. Examples of LMS include Saba, NetDimensions EKP, and SumTotal.

Perceived Ease of Use: This refers to the degree to which an individual believes using a particular information system would be free of effort.

Perceived Usefulness: This refers to an individual's perceptions of the expected benefits from using a particular IS system

Technology Acceptance Model (TAM): This is a theoretical framework designed by Davis (1989) that proposes a relationship between users' acceptance of a new IS and the users' perceptions of the ease of use and usefulness of the IS.

Usage: This is the dependent variable in the TAM, and it gives an indication of the use of the information system.

Virtual Learning Environment (VLE): An environment that facilitates the management of courses between the instructor(s) and students. It is used to be used to support flexible and distance learning.

Web-Based Course Management Systems (WCMS): These are tools that permit the management of asynchronous learning environments. Examples include WebCT and Blackboard.

The Wireless Revolution and Schools

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University of Texas School of Public Health, USA

It would be counterproductive for the 21st century student to be harnessed to a computer lab—handcuffed to place and time for learning to occur. Wireless technology frees education by equipping each student with a laptop computer or PDA and a wireless network card that provides an Internet connection.

Judith B.Rajala,
President and Founder of EduHound.com

INTRODUCTION

The current wireless revolution in our society is increasing the impending need to be able to facilitate communication and have the availability of access to information at any time, place, or medium. This notion of accessing information at any given time is an idea central to the application of wireless technology. This idea has been made into reality with the use of WI-FI technologies and wireless networks. By providing teachers with such tools for teaching to implement in various subject domains and content, schools will equip teachers in their ability to provide quality teaching and learning for the student. With the new wireless revolution, students can participate in collaborative learning that extends their current educational experience.

Amid the current wireless revolution in our society is the impending need to be able to facilitate communication and allow any time, anywhere access to information at the tips of our fingers. Norm Rose, head of Travel Technology Consulting, believes that "people will soon be able to get any information they need, wherever they are—even when, as in the case of last-minute unforeseen schedule changes or the appearance of a tasty restaurant nearby, they didn't know they needed it" (Botelho, 2003). This notion of accessing information whenever you want it, when you want is an idea central to the application of wireless technology. This idea can be made into reality with the use of WI-FI (wireless fidelity) technologies and a wireless network. Since increased access to information and the ease of communication are the main goals of the wireless revolution, the next question is how can this phenomenon impact classroom instruction? With this notion, we can commit to quality teaching and student learning.

BACKGROUND

If we reflect upon the goals of many schools, districts, and universities, they are very similar to the goals of this now popular wireless revolution. Schools and campuses around the world are constantly attempting to provide increased learning opportunities to their students. These opportunities are attained through easily accessible information resources. Instructors must also be able to communicate with all members of the learning community, such as with students, parents, colleagues, and administrators. Since various new wireless technologies have been invented in order to improve and facilitate communication and information retrieval, they seem to be optimal devices to use in educational settings. Wireless devices can provide students with increased access to Internet resources and various computer applications that have been designed to enhance learning situations. In conjunction with a wireless network, the wireless devices can provide all students access to computer technology in their own classroom environments. Students would not need to move to another environment and shift their focus on a lesson or activity when the use of computer technology is desired. Especially with the relatively current release of various mobile technologies, students can each have access to their own computer at their own desks. Schools and universities are now beginning to jump onto the wireless bandwagon by establishing wireless networks within their buildings. Several schools and universities have also adopted some of the new mobile technologies, and teachers have integrated these technologies within their curricular instruction.

MAIN DISCUSSION

Wireless notebooks, also known as wireless laptops, are one of the most widely used forms of wireless technology in schools and campuses today. Many schools and campuses are using wireless mobile labs equipped with laptop computers and occasionally a network printer, all housed in a metal rolling cart. This notebook cart allows for the automatic conversion of any classroom into a fully functioning computer lab.

The use of wireless notebooks in educational settings has many advantages. First, the lack of network cables allows more flexibility in instructional activities. Students can work in collaborative groups with their devices without being confined to a static room layout. They can even move into a different room with the devices, as long as they are in the range of the wireless network. The reduction in cords can also significantly "clean up the computing facility" (McKimmy, 2003). Second, instructional time can be saved because students do not need to relocate in order to use computers within any instructional activity. Also, in the case of using a mobile lab, each student can have access to his own computer and time can be saved because students do not need to take turns completing their assignments on the computer. By comparison, in the higher education setting, instructional time can be saved because "fewer cords means less setup time for class lectures" (DeCerce, 2001). Third, the smaller size of the laptop computers and the comfort of having the computers in their familiar classroom environment can help both students and teachers feel relaxed and not "overwhelmed by big desktop computers that neither student nor teacher can see around" (Rajala, 2003). As Jamie McKenzie (2001), the editor of *From Now On - The Educational Technology Journal*, states, "Finally we have computers that can sit on a desk with no more mess or bother than a textbook." Having computers at the students' desks creates a scenario where an instructor can move seamlessly between two classroom environments. When students have the laptop covers down, the room is an ordinary classroom. A computer lab environment results by simply lifting up the laptop covers (Levine, 2002). A fourth advantage is offered due to the increased access of computers among students. At the University of Alberta in Canada, a mobile lab can be checked out and "makes it possible for some classes to get computer access when it otherwise might have been impossible since the regular computer labs are heavily used, especially by classes that book for an entire term" (Davies, Carbonaro, & Kendal, 2003). This same principle can apply to elementary schools, middle schools, and junior high schools because those students often have to share access to one or two computer labs as well.

The list of advantages regarding the use of wireless notebooks can continue, but there are also a few issues that need to be considered. Price is often an issue that interferes with the availability of wireless devices in a classroom. Most laptops cost between $1,000 and $3,000 (Caverly & MacDonald, 2003), costing "50% to 100% more than their desktop counterparts" (McKimmy, 2003). Laptops are also harder to upgrade due to the hardware used is designated only for that particular brand and model, making it difficult to integrate future technologies (McKimmy, 2003). It is also known that laptop batteries can only last for 2 to 5 hours, unless replaced with another charged battery (students must shut down the computer before initiating the switch) or plugged into an electrical outlet with an AC adapter. This may cause a distraction in a classroom or loss of instructional time, as well as an increased need for surge protectors (increasing wires and cabling). Security can also be an issue if a wireless network and security protocols are not configured properly. Most wireless networks, including the more common 802.11b standard, provide "a form of encryption known as WEP (Wired Equivalent Privacy), however it is notoriously weak" (McKimmy, 2003). If configured properly through additional security measures, wireless networks can be relatively safe features. According to McKimmy:

> One option is to control access to the network based on the individual machine's MAC address (message authentication code), a unique number that identifies its NIC (network interface card). Unknown computers may be denied access if their MAC address is not in an authorized list. Other alternative to method listed previously is the notion of the VPN or the virtual private network system.

Another issue that often comes up is that students may begin to use their laptops for purposes other than the classroom task at hand. With the capability of Internet access, instant messaging, and various computer games, wireless laptops can often detract student attention from the lesson. However, Lawrence Levine (2002), a teacher of mathematics, has found software applications, such as CrossTec Corp.'s "NetOp School" and SMART Technologies' "SynchronEyes," that help teachers or instructors monitor student laptop use. According to Levine, these programs "allow instructors to monitor and take control of a student's machine, as well as project the screen of a student's laptop so that everyone in class can see it." In this way, students are discouraged from using their laptops for purposes other than class-related uses.

Despite some of the issues raised against the use of wireless laptops, there have been many successful scenarios demonstrating their benefit to educational environments and student learning. Several schools in Louisiana, through a project called Project CREATE (Careers, Research and Exploration, Application, and Technology Education), a wireless mobile computer lab was used to help ninth grade students improve their technology skills and conduct a research project. Students used word processing skills and electronic and Internet-based research skills to create a research project based on a career. The students also created a portfolio compiling their best writing and computer application activities. Due to this project, "Mandeville High School's Iowa Test of Educational Development (ITED) scores rose an average of 20%, thus, contributing to an overall increase in the school's 2002 performance score." In addition, "363 of 365 students scored 75% or higher on the final checklist, which included computer application skills such as creating and formatting word processing documents, envelopes, labels and tables, as well as collecting data in a spreadsheet and insetting it in a word-processing document" (Styron & Disher, 2003).

Levine (2002), at the Stevens Institute of Technology in Hoboken, New Jersey has also used wireless laptops to teach his students mathematics. He often provides a complete set of class notes that are available to his students on the Web. He mentions that the students can download the notes after class. However, it seems that notes can also be referred to in class with the use of the wireless laptops by having each student find the class Web page. Following an in class lecture, Lavine also prepares an activity for his students to complete with the use of their laptops to help reinforce the concepts presented in his lecture. He notifies his students when the use of the laptop is appropriate in class by asking them to put their laptop cover up. Levine realizes that some challenges can arise with the use of wireless laptops in the classroom, but he feels that "the effort expended to deal with these challenges is more than compensated by the opportunities that such classrooms present to utilize technology as a teaching and learning tool."

Even though the use of wireless laptops seems more prevalent among elementary, secondary, and higher education students, preschool students are also benefiting from the use of wireless laptops. At the Primrose School at Bentwater in Atlanta, Georgia, teachers use wireless laptops to engage students in curricular based lesson activities. For example, during small group instruction on a unit about air transportation, each of eight students uses a laptop to learn more about hot-air balloons. Their teacher helps them turn on their laptops, access the Internet, and connect to a preselected Web site on the Albuquerque International Balloon Fiesta. While visiting this Web site, students learn how to count balloons, recognize different shapes, and look at an image of the inside of a hot-air balloon while their teacher explains how these balloons work. The Web site also gives students an idea for the type of balloon they would like to create for the art project they will design following their 20 minute mini-lesson (Scott, 2003). Many believe that technology activities are not developmentally appropriate for young students, but this example definitely provides proof that even small children can benefit from the use of wireless technology.

Handhelds, commonly referred to as personal digital assistants (PDAs), are slowly gaining popularity in instructional settings. Their pocket-sized portable feature makes them easy to manage and use in the classroom. Akin to the wireless notebooks, many PDAs also now have integrated wireless capabilities that allow students to use the Internet and perform various network related functions when in the range of a wireless network.

There are several advantages to using handhelds in the classroom for both instructors and students. First, when comparing the price of a handheld to the price of a laptop, there is a large discrepancy. While laptops cost thousands of dollars, handhelds cost hundreds of dollars, "with basic models starting at less than a $100" (Caverly & MacDonald, 2003). The affordability of a wireless PDA vs. a wireless laptop may indeed make these devices eventually one of the more popular choices among wireless devices used in the classroom. In addition, since PDAs are "using two major operating systems (Palm OS or PocketPC OS, with Blackberry OS a distant third), applications for these devices are prolific and platform ambivalent" (cited in Caverly & MacDonald, 2003). The availability of various software programs at shareware sites that are usable on different PDA models allows these devices to be more accessible to all users. These software applications include tutorial and tool software available on regular computers. Along with these applications, PDAs provide students and teachers with organizational management. Students can schedule appointments, store addresses, make to-do lists, respond to e-mail, make calculations, track assignments, and read e-books. Programs such as "4.0 Student (Handmark, 2003) or Active Student Organizer (Siang, 2003) track homework, quizzes, test details, due dates, scores, textbooks, grades, and even forecast GPA" (Caverly & MacDonald, 2003). Teachers can use PDAs in a similar fashion to obtain instant access to student records and grades from a school server. Specialized tutorials have also been created to help students with vocabulary, science, grammar, foreign languages, and other subject areas. PDAs can also provide support for students with disabilities, due to text-to-speech readers and spell checkers that pronounce words and definitions (Caverly & MacDonald, 2003). One of the most distinct features of a PDA that differentiates it from a desktop or laptop computer is its infrared beaming capability. With this capability, students can easily transfer files either to their peers, to their teacher (who can instantly assess the work, store the grade on a spreadsheet, and beam it back to the student), or maybe eventually store them on a local networked server. The files can also be synched to a desktop or laptop computer for additional storage.

Although the personal desk assistant has several notable advantages, there are still many features that need to be improved. Viewing Web sites composed of several frames can be frustrating and sometimes not accessible. In addition, it can be bothersome to have to continuously scroll both horizontally and vertically to view an entire Web page due to the small screen size. According to Caverly and MacDonald, "the version of Office packaged on PocketPC PDAs is limited, not allowing formatting or tables in word processing, charts in spreadsheets, editing or animation in a slide show, or frames in Web pages." All of these limitations can be slightly frustrating in an educational setting. Some administrators have also discussed the misuse of PDAs in educational settings. They are afraid that students will use these devices to cheat on tests, play games, or send notes and e-mail to their friends (Trotter, 2001). In one instance, a student "installed a software program that turned his PDA into a remote control for the classroom TV, which allowed him to turn it on and off from the back of the room" (cited in Yuen & Yuen, 2003). Regardless of these limitations, there have been several successful programs initiated that demonstrate the educational benefits of using PDAs within the classroom environment. In a history class at Stagg High School in Oakland Park, Illinois, students used Palm III handhelds to check stock prices on the Internet and write reports about the management of the fantasy stock portfolios they created by using the foldable keyboards as input devices (Trotter, 2001). At that same school, in a geography course, students used their handhelds to create a concept map, using *PiCoMap*, which they could then beam to their peers or their teacher with the infrared beaming feature (Trotter, 2001).

In Hartland, Michigan, sixth graders at Hartland Farms Intermediate learned about the polar regions of the earth. They were required to investigate a particular polar animal. In order to do this, the students used their Palm handhelds to record facts they found in magazines such as *National Geographic*. They were also able to use *FlingIt* to send Web pages about their topic to their handheld devices. Students then beamed these useful resources to their group members and interested peers, so that they could have off-line access to the pages at home. After their research on a polar animal, the students took a trip to the zoo and could document their trip or any new information that would contribute to their research project with Kodak PalmPix cameras (Curtis, Luchini, Bobrowsky, Quintana, & Soloway, 2002). Programs on the handheld and peripherals associated with the handheld were used to enhance this group of students' learning experiences.

Teachers and administrators have also found that handhelds can be used as excellent tools for the purpose of increasing home–school communication. Strom and Strom (2003) conducted a field test, with the cooperation of Motorola, on high school students from low- and middle-income households. Faculty from that school were asked to use a PDA to record both positive and negative student behaviors and send those to parents throughout the day using a pager messaging system. Both parents and teachers were given a School Code of Recordable Events (SCORE) card that had 50 predetermined statements that describe typical behaviors of students assigned to a certain code. Teachers were to use these codes to send messages to parents throughout the day about their child's behavior. In this way, parents would receive more immediate feedback on both positive and negative behavior and could provide their children with the proper form of reinforcement or punishment. According to Strom and Strom, "the requirement of immediacy for giving parents feedback about student behavior is an important condition of effective positive or negative reinforcement and punishment." At the conclusion of the field-based portion of the study, surveys were distributed to faculty, parents, and students. The results of the surveys "confirmed that use of personal digital assistants and pagers can improve communication between the school and home" (Strom & Strom, 2002). Hence, PDAs can not only provide direct educational benefits to students, but can also facilitate communication between all members of the learning community.

Tablet PCs are one of the newest forms of wireless mobile technology. They preserve the relative screen size of a laptop computer, but function much like a PDA due to the use of a stylus as an input mechanism. Both quantitative and qualitative research has been conducted on the educational benefits these devices may provide. Although this device is in its infancy stage in relation to its use in educational settings, many of its features have been found beneficial to learners. The handwriting recognition feature and the ability to save notes written in *Windows Journal* in either handwriting form or as digital text can allow students to preserve the notes as if they took them on a sheet of paper or search their digital notes for certain keywords or phrases. Like both the wireless notebooks and PDAs, Tablet PCs allow for flexible educational settings, where students can form collaborative groups and still have access to their own wireless device. Tablet PCs can also provide students with instant assessment, just as PDAs do, with the use of handwriting recognition features. Instant polling, brainstorming, and results from team and group activities can be easily shared with the entire class due to the Tablet PC's wireless networking feature. With programs such as *Silicon Chalk* and *Colligo*, "users can discover one another, set up connections, and start to communicate in an informal manner" (Lomas & Rauch, 2003). This feature of the Tablet PC encourages the formation of collaborative learning groups, a common occurrence within constructivist learning environments. Alternative methods of input, such as keyboard, stylus, and voice recognition are also available. This may provide increased accessibility by addressing the varying needs of different learners. Another important advantage of the Tablet PC is its portable size, lightweight feature, and adjustable monitor and display settings, allowing it to take on the functionality and practicality of an ordinary class notebook with the additional benefit of advanced computer technology.

Similar to the wireless notebooks and handhelds, Tablet PCs also have a few issues that need to be addressed. First of all, since Tablet PCs are a rather new form of mobile technology, the cost of the Tablet PC usually exceeds the cost of a wireless notebook, most pricing well over $2,000 (Ashenhurst, 2003). However, this price will most likely decrease as the demand for Tablet PCs increases. Based on personal experience with a Compaq Tablet PC TC1000, Tablet PCs also seem to download information at a slower rate their wireless notebook counterparts, maybe due to the combination of processor speed and memory available. Another cumbersome aspect is that a CD-RW/DVD drive would have to be attached as an external drive. Thus, the only means for backing up data or transferring files without an external drive are through the USB ports. Even though a few issues may exist, Tablet PCs have been used successfully in educational environments. At Sharon Academy in Vermont, Art teacher Ed Koren uses Tablet PCs to help students draw. He states that students often get upset during the drawing process, but by using the Tablet PC, students can "do it without fearing that they're going to make a mistake. They can always go backwards, or can erase, or they can just start again. The Tablet PC accents and influences the quality of the work that the students are able to do" (cited in "Freedom and versatility," 2003).

Comparatively, at Ocoee Middle School, "when students come into the classroom, they log onto their Tablet PCs and go to Microsoft® Class Server 3.0 where they can find their assignments, worksheets, and quizzes, allowing them to be self-directed and work at their own pace. Teachers access each student's work through Class Server where they can correct assignments, provide immediate feedback, and enhance their ability to individualize curriculum" (cited in "Tablet PCs Go to School," 2003). Since the Tablet PC is one of the newest forms of mobile technology, several studies are still currently underway and should provide more real-life examples that demonstrate the benefits of the Tablet PC in educational settings. The similarity in the functions of this device with the wireless notebooks and handhelds, in combination with the additional new features present only in the Tablet PC, will surely provide increased benefits in communication and information retrieval within educational environments.

CONCLUSION

Looking back upon all of these wireless mobile devices, it seems that classrooms have and are continuing to become part of the current wireless revolution. The wireless notebooks, handhelds, and Tablet PCs have all been used in various ways within different educational settings. However, all of these wireless mobile devices have demonstrated their capability of enhancing and benefiting all members of the learning community, including students, teachers, professors, administrators, and parents. These devices provide the learning community with improved communication and invaluable resources. The devices truly support the any time/anywhere learning philosophy and have proved that they can be used in educational settings not to use technology for technology's sake, but to use technology to support and enhance learning situations. The Technology Department at the Brunswick School in Greenwich, Connecticut, a private, independent college preparatory school for boys in grades PreK-12, sums up the idea behind using mobile technology rather nicely by noting that "it would be counterproductive for the 21st century student to be harnessed to a computer lab—handcuffed to place and time for learning to occur" (cited in Rajala, 2003). With the new wireless revolution, students can participate in the any time, any place learning that seems to provide the most natural learning environment.

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KEY TERMS

Education Technology: The use of information, communication, and technological devices and processes to enhance, extend, and engage, the teaching and learning process to promote quality teaching and active student learning and engagement.

Handheld: Handheld devices (also known as handhelds) are pocket-sized computing devices that are rapidly gaining popularity as the access to information in every walk of life becomes more and more mission critical.

PDA (**Personal Digital Assistant):** A portable computing device for organizing personal data such as telephone numbers, appointments, and notes. It technology device is capable of transmitting and receiving data when equipped with a wireless module.

Tablet PC: A computer shaped in the form of a notebook or a slate with the capabilities of being written on through the use of digitizing tablet technology or a touch screen.

Wireless Application: Wireless application protocol (WAP) is an application environment and set of communication protocols for wireless devices designed to enable manufacturer-, vendor-, and technology-independent access to the Internet and advanced telephony services.

Wireless Technology: The term wireless technology is generally used for mobile IT equipment. It encompasses cellular telephones, personal digital assistants (PDAs), and wireless networking.

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