EDUCATIONAL TECHNOLOGY

> If we truly engage in the challenge of transforming education with the assistance of the technological tools we have invented, then we will have gone a long way toward building a future in which we can all thrive. Our challenge, quite simply, is to use our tools to prepare people for their future, not our past. (1)

Our schools were designed socially, politically, and technologically for the industrial era. Throughout history, new technology has ushered in new social, cultural, and political orders. Computers and telecommunication systems have changed the social order of the industrial era to the communication era. These changes need to be reflected in our schools. This will occur as educators design for diversity in students' needs and authentic learning activities. The type of cultural change that technology is catalyzing necessitates changes in the roles and functions of students, teachers, the curriculum, and the educational institutions themselves.

In the corporate world, the notions of "one size fits all" and mass production have largely been abandoned in favor of careful and continuous assessment of customer demands, provision of customized products and services, niche marketing, and just-in-time implementation of processes and materials (2). In many workplaces, work is more self-paced and self-directed than in the past, with functions being outsourced, leading to dependence on just-in-time suppliers, who are outside the traditional factory setting.

Employers have long been aware of a disconnection between education and the workplace. Rapid technological and social change is pervasive outside of schooling, but educational institutions appear to be exceptionally resistant to change, especially at the postsecondary level (3). Given that the missions of the corporation and schools are different, what lessons can educators learn from business regarding changes in the post-industrial society that will help better education? Some of the changes discussed below involve elementary and secondary education, and others are more relevant to postsecondary schooling; taken together, however, these

shifts point to changes in education that reflect the changes in post-Fordian society.

Fordism

The automotive industry is the model industry of modern times. The various forms of production adopted by automotive assemblers over the years "are the paradigms for production elsewhere in society. Fordist education emphasizes mass education, reduced student course choice, and increased divisions of labor" (4).

What turns education on its head is that students have access to information. Teachers no longer need to be the sole or even primary source of information. For roughly the past 150 years, the command and control structure characterizing organizations has been set to relay orders downward and information upward (5). This breaks down once information technology makes information available to all persons.

Post-Fordism

In the industrial age, students went to schools. Today in the communication age, schools go to the students (6). It is for this reason that teaching and learning at a distance has rekindled the changes discussed here. The *distance educators* are speaking about change in the nature of schooling, and it is in this body of literature that is found the most writing on the subject of technology-mediated learning and teaching in the post-Fordian society. Post-Fordism is characterized by a high level of labor responsibility, low division of labor, high decentralized, low mass-marketing, low mass-production, and short product life cycles. Thus, academic staff must be rewarded for rapid adjustments to course curriculum and delivery as demanded by the changing needs of the students (7).

Why Change from Fordist to Post-Fordist Teaching and Learning?

Greville Rumble (4) builds a strong case that a Fordist model of education will fail in today's world, and post-Fordism will prevail. Just-in-time production, quick prototyping, outsourcing, and flexibility are just a few of the methods in the agile, flexible educational organization necessary in the post-industrial society (8). Engineering, and the world's workplace generally, are diverse and fragmented, rather than standardized and homogeneous as they were in mass society (9). The change to a post-Fordist society, and the reflection of this in education, has pervasive implications for the changes in higher education and the engineering curricula, as it has already in industry. While the term "post-Fordism" includes many different streams of thought, most writers on the subject contend that new technologies and more flexible work practices demand an increased level of skills and knowledge from educational and training systems (10).

Since the time of Socrates, students who want to learn under a particular teacher's guidance have had to seek out that teacher and spend time in his or her presence. Those in compulsory schooling have had little choice in the matter and, in postprimary grades, have been typically shuffled from room to room to sit in front of the "experts." Likewise, trainers in business and industry have typically taken students out of their workplace and gathered them in a central location. Teachers, professors, and trainers, using this mass production model, must pace the instruction within the confines of class periods/quarters/semesters, with little apparent regard for the time that *learning* can sometimes take. Today, adult students' lifestyles attach value to part-time study and to study when and where convenient for each of them. Business managers can no longer afford to have their employees leave for hours or days or weeks at a time for training at a central location. The training must go to the students, and arrive just in time (11). For these and other reasons, demographics and competition will no longer allow educational institutions to unilaterally insist upon "my place at my pace." The pace of learning is hard to control, while the pace of teaching is much easier to control. What is needed is education to be available at a distance, or alternatively an implemented model of distributed or decentralized learning.

> The most exciting potential of interactive communications is that it enables a new concept of "on-demand learning." In a world where the amount of information available is exploding, and knowing how to learn may become more important than what one knows, emphasis for most people may be on learning broad competencies rather than tightly focused disciplines. The networks allow an individual to reach out anywhere for specific training in a given area at the time it is needed. The promise of on-demand learning fueled by the advances of digital libraries, networked courses, archives of news and current events, and the simulated learning environments made feasible by virtual reality, offers enormous benefit to all sectors—commercial, government, educational, and nonprofit. But only at the cost of a transformation or reinvention of our educational infrastructure. (12)

Formal educational experiences in the twenty-first century will not be confined to classrooms or corporate training rooms. We will find learning and training occurring everywhere and anywhere there are learners or trainees, just in time for the needs of those learners rather than just in case for the convenience of traditional educational institutions and corporate training departments. The necessary information resources to support learners are in diverse formats and, increasingly, as global in their distribution as the learners are.

Cautionary Notes

The ideas expressed here are not new. Many—such as authentic learning activities as a way to teach problem solving, and the need for other critical thinking skills—have long been recognized. Many problems have arisen because concepts in education have been viewed as dichotomous rather than continuous variables. For instance, a central theme in the literature in contemporary educational reform is that education should be process-oriented. This idea is often treated as opposed to, or the opposite of, knowledge-based learning. Another way to view this concept is as a continuum, with different learning activities each falling somewhere along the knowledge–process continuum. The right mix between process and content acquisition is needed for effective learning. The focus below is on a process orientation, but it must not be to the exclusion of all other methods of learning (13). Similarly, not everyone agrees with the post-Fordism described below as the best framework in all learning situations (14).

The challenge for educators is not to choose between bipolar opposites but rather to decide what the most effective combination of learning activities is. So, as you read the following ideas, remember that while I may in some cases strongly ad-

vocate moving toward one end of a continuum *as an overall strategy,* in some contexts it is appropriate and necessary to move toward the other end of that same continuum for the most effective or efficient learning to occur. How to choose the appropriate blend of learning and teaching activities, when and how to balance often competing philosophies, is the challenge for tomorrow's educators.

TECHNOLOGY'S ROLE

If you stripped computer and telecommunication systems from contemporary businesses, I am not sure how many corporations would survive. Speaking of the extent to which the very survival of today's businesses depends upon the technological changes that have occurred over the last decades, Postman (15) states:

> Technological change is neither additive nor subtractive. It is ecological. I mean "ecological" in the same sense as the word is used by environmental scientists. One significant change generates total change. If you remove the caterpillars from a given habitat, you are not left with the same environment minus caterpillars: you have a new environment, and you have reconstituted the conditions of survival; the same is true if you add caterpillars to an environment that has had none. This is how the ecology of media works as well. (15, p. 18)

One could build a case for this being true not only in business but also in leisure activities, and in society in general. I doubt that the survival of the educational system would be in danger if computers and telecommunication systems should be stripped from within our current educational institutions, given the way technologies are currently being used in schools now. What could we be doing with technology in schools that would cause it to be missed if it were to cease?

Technology could be used to provide a mechanism for shifting from school-based learning to a pattern of lifelong learning that is needed by all citizens. Unless adjustments are made to the ways we deliver instruction, assess student performance, and issue credentials, Froeschle and Anderberg (2) believe that colleges and universities will be displaced in the market by small, nimble private for-profit competitors that operate on a model more akin to high-performance work organizations in the corporate world. Thornburg (1) echoes this:

> The issue, quite simply, is how we transform education to meet the needs of today's students. Make no mistake, education will change whether or not we drive that change.. . . Unless we move quickly to take proactive control of the change process, our educational institutions may become irrelevant to the education of our youth. If that happens, our educational institutions will simply disappear. (1)

Changes in the workplace and society outside of school are not driven by a desire for efficiency or for doing the same things faster. Rather the changes in business are about effectiveness—about changing what it is important to do (16). The focus in today's business is not on better management, but on better leadership.

THE GOALS OF EDUCATION

The purposes and goals of education, what is valued, may be derived from several sources—society, employers, the curriculum, or the individual learner—each competing for and contributing to the overall purposes of education. Definitions of what constitutes quality education are dependent upon one's assumptions regarding the educational process.

For those educators who believe the curriculum generates the goals of education, the underlying assumption appears to be that teaching can be evaluated separately from learning. Essentially, those educators believe a set body of knowledge exists and the efficient, quick transfer of that knowledge is what defines excellence in teaching. Lecture, drill and practice, demonstration, and showing students a video are examples of what those educators would consider appropriate methods to meet these educational goals. No notice is taken of students' individual learning styles, and it is expected that learning will be accomplished by all students within the same time frame when taught using the same techniques and methods. In this mass-production model of education, the teacher is front and center—the expert, the source of the correct answers.

Similarly, when the purpose of education and training is dictated by an employer, knowledge is often valued to the extent that it will immediately contribute to the workers' job performance (17, p. 57). Historically, employers have expected schools to mass-produce graduates with the skills and knowledge that the employers most need in their new employees. To meet this purpose, teacher-centered and standardized approaches to education and training are most efficient.

Our society is a democracy, and some scholars have strongly advocated the preparation of citizens for life in a democratic society as a primary goal for education. When Thomas Jefferson conceived of our public education system, he realized the critical foundation for a democratic society that is provided by education based on free and independent thought (18–20). There are certain shared values, beliefs, language, and habits of thought that arguably determine the survival of a democratic society. It is a fundamental need in our schools that we explore what our society believes and values and what our leaders tell us is right. It is just as basic that citizens be exposed to examples of totalitarian and nondemocratic systems of thought and government to render the contrast self-evident. The higher-order cognitive and critical thinking skills demanded by a democratic society, developed under the guidance of teachers who are not driven by a centrally dictated curriculum, require different teaching strategies and methods than those that conveniently prepare students for production line labor in an industrial society. The need to develop higher-level cognitive skills demands opportunities to "negotiate learning objectives, encourage students to critically analyze course content for the purpose of constructing meaning, and then validate knowledge through discourse and action" (21, p. 12).

EVIDENCE OF SCHOOLS DESIGNED FOR THE INDUSTRIAL AGE: WHAT SCHOOLS SHOULD *NOT* BE

There is a significant difference between the ideals of efficient authoritarian transmission of knowledge using direct instruction methods, leading to passive, unquestioning learners, and challenging learners to construct meaning within a democratic community of learners by using a more indirect learner-centered teaching style. Linda Darling-Hammond (18), in her

presidential speech to the American Educational Research Association Annual meeting in New York, concluded that today's schools were designed 100 years ago and education was organized into discrete, repeatable operations (very much like a production line):

> Modern schools were developed to limit diversity, to create as much homogeneity as possible in the ideas under study, the methods of instruction, and the students convened to study together. Like manufacturing industries, they were designed as highly specialized organizations—divided into grade levels and subject-matter departments, separate tracks and programs—to facilitate the use of routines and procedures.
>
> . . . Students move along a conveyor belt from one teacher to the next, grade to grade, and class period to class period to be stamped with a lesson before they pass on to the next. They have little opportunity to become well known over a sustained period of time by any adults who can consider them as whole people or as developing intellects. (18, p. 13)

Darling-Hammond contrasts these images with what democratic schools seek: "diversity in people, perspectives, and ideas and . . . to learn from those multifacted experiences and expertise" (p. 18, p. 12).

Seymour Papert (22) describes what schooling has been in the twentieth century, and what they *should not be* in the twenty-first century:

> The segregation of children by age is such an absurdity. I talked to a group of educators recently, and I said "Before I talk to you let's put the 20 year old there, the 22 year olds there, and so on." Nobody would do that. It is absurd. We do it for kids because of this fragmented way of handing out knowledge in order to systematize it. And you'd better divide the day into periods, and the kids into grade levels. . . . Many of these things are so associated with school that it is hard for people to shake them off. I give talks about this sort of thing to educators and at the end they say, "Well exactly how is the computer going to help me teach fourth-grade math?" And that's exactly the wrong question—there's not going to be a "fourth-grade." There's not going to be a separate math class. There's not going to be teaching. (22)

So, rather than using technologies to replicate factory-style schooling methods (23), the educational system's challenge is to foster a technologically mediated environment that will expedite the change to lifelong learning necessary by each citizen (24). This shift is not going to occur by making incremental changes to the industrial-era model, nor will information technology alone bring about the necessary changes. For example: throughout history, those who have controlled the printing presses have been empowered and have controlled the distribution of information and the formation of public thought and opinion. With the use of electronic technologies people who have access to the technology can become publishers of their own thoughts and ideas.

Even so, it is not the use of technology to publish that will empower individuals most, but rather its use to communicate, which will power the current transformation in education:

> The essence of this revolution is a new communications medium that puts power in the hands of individuals, completely reinventing our ability to reach people, acquire information and distribute knowledge. . . . The driving force in the communications revolution is interactive communications. This new communications medium already links millions of people around the globe with networks of computers and telecommunications devices. . . . It has been rightly observed that, in terms of individual and organizational success, the movement toward a Communications Age puts far greater emphasis on education and "intellectual capital" than almost anything else. The people who hold knowledge, or who know how to locate or create it, are the ones who will thrive. Interactive communications has the potential to reinvent learning and the delivery of education in ways never before possible. (12)

In contrast with distance learning using text and tests, videotapes, or television, computer and telecommunications technologies that are capable of two-way interaction do more than duplicate the student passivity found in many classrooms or just broadcast the activities of the teachers lecturing and demonstrating in front of a camera—they change the balance of power (25) in the classroom. Communication technology makes possible the methods, processes, and facilities for continuous, lifelong learning because everyone, children or octogenarians, can find the educational materials that they need (12).

THE COMMUNICATION ERA: WHAT TWENTY-FIRST-CENTURY SCHOOLS SHOULD BE

Necessary change is difficult and uncomfortable for most people even when they discover what was once valued is not any more. The general direction of these shifts in what is valued by society and in the workplace is away from assembly-line-style activities to teamwork, away from abstract theorizing to applying theory, away from putting in seat time to active problem solving, away from schooling only for the young to lifelong learning and professional development, away from discipline-specific content to multidisciplinary process skills, and away from instruction that is teacher-focused to learner-centered education.

Schools are more efficient than ever at teaching students. Unfortunately, the problem may be as Covey (18) suggests in his analogy of climbing the ladder of success in better and better ways, only to find out when reaching the top that the ladder is leaning against the wrong wall. Are we training and educating students better and better for life in a society that has already changed and for jobs that we know a lot about but that no longer exist? Educators are challenged today to prepare students for a future in which the skills and knowledge that will be needed are not known. (In fact, in many fields, the pace of change is so quick that not only are the skills and knowledge that will be needed tomorrow unknown, they are also unknowable.) So the challenge is not to use new technologies to do old things differently, but to do different things all together.

Contrast the industrial-age model of education with the scenario by the National Academy of Sciences:

> In a year-round model, schools might be open all day and all year, with groups of students rotating in and out of session. Following the trend toward multi-age grouping, classrooms might include students of different ages. Traditional 50-minute classes will stretch or disappear to accommodate activities made possible by technology. A multidisciplinary approach toward teaching and learning will result in longer-term projects that cut across disciplines, combining the subject matter of previously separate classes. Multiple choice tests will be replaced by new kinds of assessments that measure the acquisition of higher-order skills. The

> ultimate goal of this new model of education is to foster communities of lifelong learners, where intellect and cooperation are highly valued. Within these communities, decisions will be made by those in the best position to make them—by students, teachers, and educational administrators. The elements of this new model of education are starting to appear in scattered communities across the United States. Schools are experimenting with new organizational structures, new forms of governance, and new uses of technology that are designed to reflect the constant flux of modern society. This trend is about to accelerate dramatically. As distance learning technologies become more powerful and plentiful, and as the needs of society more urgently call for a new model of education, American schools will be caught up by irresistible forces of change. (26)

Extension of this scenario can be made to higher education and corporate training.

ENVIRONMENTS RICH IN DIVERSITY AND AUTHENTIC LEARNING

The goals of many contemporary educational reform efforts include persuading educators to create environments that are rich in authentic learning, that are interdisciplinary, and that promote diversity expressed in multiple-age classrooms, students learning together at different stages at the same time, and students seeking out and using diverse resources and sources of knowledge.

Authentic Learning

Today's educational reform efforts seek to foster a post-Fordian, constructivist style of learning. This can be characterized by attempts to move classrooms away from teacher-focused, didactic instructional approaches in which teachers do most of the talking. Students are instead challenged by their teachers to solve complex, authentic problems that involve "lengthy, multidisciplinary projects, cooperative learning groups, flexible scheduling, and authentic assessments" (27), p. 16). Over the past decade and a half, there has been a significant increase in the use of classroom assessment based on performance geared to real-world situations and the development of student portfolios in schools (28). Rather than teaching social studies, mathematics, history, and writing as separate and distinct operations in an assembly-line approach, teachers and administrators are beginning to realize that real-life problems are not that discrete. See, for example, the *Jasper Project* (29–34).

Blending Learning Across Disciplines

Schooling often presents an apparently static view of a field of study. Students are given the impression that there is an immutable "body of knowledge" that must be memorized to know a subject (e.g., biology, US History, literature), when in fact what they are being taught is a foundation of shared language and information on which they can build their socialization into their disciplines. Scientists, scholars, and professionals know that their fields are dynamic in nature and not discretely compartmentalized, as students might surmise from their segmented instruction. Today's "facts" and theories may very often be disproved tomorrow. Further, not only are their fields dynamic and ever changing, but they are linked with many other disciplines.

To design courses that show these dynamic interdisciplinary links is a difficult challenge. Even so, demand is rising for the integration of school subjects: a conceptual convergence of the natural sciences, mathematics, and technology with the social sciences, the behavioral sciences, and the humanities into a coherent whole. In classrooms, teachers can use technology such as video footage to view social or natural phenomena, using a team-based project-oriented approach that provides much richer, authentic, and interdisciplinary learning experiences. Technologies, such as hypertext and hypermedia, allow advanced students to analyze and investigate links to multidisciplinary information in a way that was impossible a few years ago. This can often lead to stronger interest and motivates the students to further exploration and synthesis (35,36). Today, with learning webs and hypermedia, the emphasis is on nonlinearity and multiple pathways to knowledge. Hypermedia works well for students used to self-pacing and problem-solving: less skilled and less disciplined students seem to slip between links in the web and get lost and drown in a sea of disorganized, unedited, and unvalidated information.

Multiage Classrooms

Multiage/multigrade classrooms are certainly not new: they have ranged from the one-room schools of the turn of the century to the ungraded classroom of the 1960s and 1970s, to the cost-effective dual-grade classrooms of today. Fetzer and Ponder (37) argue that the best alternative to assigning children to grades on the basis of birth date alone is to implement a child-centered and process-oriented curriculum. While teachers should be prepared and trained to use such methods as cross-age tutoring, self-directed learning, and individualized teaching, and to organize and manage their classrooms for student responsibility for their own learning and to facilitate independence and interdependence (38), recent research suggests that major benefits result from multiage grouping (39).

The Current Emphasis Is on Everyone Learning the Same Thing at the Same Time in the Same Place

There are systems barriers to learning, too. Teachers and trainers have the power collectively to change much of what is done in schools. Still, all educators are needed to make systematic changes. For instance, human learning is not confined in time; only teaching events are. What if the 52-minute class period is too short a time to think through a problem? Should learning be tabled because the bell rings? School is the only place that habituates people to regularly fragment their topical thinking and curtail learning into discrete time periods. The school calendar needs similar review. Should the school calendar still be set with summers off so that students are free to help with the field work on the farm (40)—giving the impression that there are seasons for work and seasons for learning?

CHANGING ROLES AND FUNCTIONS OF STUDENTS, TEACHERS, TEACHING STYLES, CURRICULUM, AND INSTITUTIONS

Changes to the curriculum and the political structure of schooling demand concomitant changes in the roles and func-

Table 1. Summary of Changing Roles and Dimensions of Students, Teachers, Curriculum, and Institutions

Changing students' roles	• From students as passive receptacles for hand-me-down knowledge to students as constructing their own knowledge • Students become adept at complex problem-solving activities rather than just memorizing facts • More activities in which students refine their own questions and search for answers • More collaborative/cooperative assignments with students working as group members; group interaction significantly increased • Increased multicultural awareness • Students working toward fluency with the same tools as professionals in their field • More emphasis on students as autonomous, independent, self-motivated managers of their own time • Discussion of students' own work in the classroom • Emphasis on knowledge use rather than only observation of the teacher's expert performance or just learning to pass the test • Emphasis on acquiring learning strategies (both individually and collaboratively) • Access to resources is significantly expanded
Changing teachers' roles	• Teachers' role changing from oracle and lecturer to consultant, guide, and resource provider • Teachers become expert questioners, rather than providers of answers • Teacher provides structure to student work, encouraging self-direction • From a solitary teacher to a member of a learning team (reduces isolation sometimes experienced by teachers) • From teacher having total autonomy to activities that can be broadly assessed • From total control of the teaching environment to sharing with the student as fellow learner • More emphasis on sensitivity to student learning styles • Teacher–learner hierarchy is broken down
Changing curriculum/ methods	• From discrete steps to cumulative problem solving • Multidisciplinary, teaching for depth versus breadth in a problem-based approach • Emphasis on multiple perspectives and a variety of explanations for a phenomenon; realizing there is not just one right answer • Project-oriented, experiential, task-oriented • Apprenticeship model; authentic, real problems; learning interwoven with work • More emphasis on the learning process with a goal of exploration and discovery (as opposed to product) • Access to resources is significantly expanded • Self-paced learning encouraged • More time to reflect on ideas and exchange ideas
Changing institutional roles	• From delivery of place-based services to multiple locations • Classroom becomes more global and multicultural • Students expect access to just-in-time learning rather than by semester or quarter • Universities demanding more flexibility in accreditation • More interinstitutional collaborative efforts, while competition among institutions increases • More attention to learners, especially those persons with disabilities and special needs • Recognition of greater need for lifelong learning (retraining and continuing education) in society • More flexibility in structuring faculty rewards, promotion, and tenure • Learning opportunities for all students are equalized

tions of students and teachers (for a summary of changes, see Table 1). The National Academy of Sciences (26) states:

> In the new model of school, students assume many of the functions previously reserved for teachers. In small groups, individual students act as peer-tutors for others. Because they are often the ones most familiar with new technologies, students lead by example, helping their classmates work through problems. In this way students begin learning from an early age how to communicate and how to assume greater responsibility for their own education. Teachers, in contrast, change from being the repository of all knowledge to being guides or mentors who help students navigate through the information made available by technology and interactive communications. . . . Schools may emerge in unlikely places—such as office buildings—or more conventional schools may have branch campuses integrated into businesses, hospitals, or homes. (26)

To work toward changing models is important as educators improve teaching and learning. It takes courage to move away from the idea of classroom lectures and demonstrations of stable content, delivered by expert teachers to students who are homogeneous, passive recipients and who work alone as they learn (41).

Students

Students with Internet access can explore topics of their choice and acquire needed information from any location from which they have Internet access. A just-in-time approach has been adopted by business and industry for decreasing costs in such areas as inventory and increasing productivity in training. A similar approach must be adopted in formal learning situations. New intellectual skills should be learned and

knowledge acquired and then immediately used (1), thus increasing the relevance of the learning experience to the student. The return of adult learners to formal educational settings has increased, raising the mean age of the student population above the traditional 18 to 24 years. Many students no longer are looking for a residential college experience, as they have already established homes of their own. For these students, having learning come to them at home or work and on a convenient time schedule is very beneficial. Adult learners are especially motivated if their educational program involves practical work or information, or helps them develop skills that can be applied immediately, as this fits in with their need for professional development, self-improvement, increased personal or team productivity, new work skills, or preparation for a promotion or advancement (42, p. 10).

Changing Teachers' Roles

While teachers will continue to fill many different roles, the balance among those roles will change somewhat. Some teachers and most students have perceived a teacher's primary role as the authoritative knowledge base and source of direction in learning. In this paradigm, information is viewed as an esoteric and scarce resource to be discovered, organized, predigested, and then doled out by teachers. On the contrary, information is increasingly perceived as an infinite resource that educators can help students learn to access, evaluate, and use (1). Teachers can model their enthusiasm for continual exploration and learning, then demonstrate their research and information analysis skills to show students how to use those same tools.

The traditionally hierarchical social and power structures in the schoolhouse are breaking down:

> Interactive communications blurs the lines of authority, that are normally imposed through controls such as hierarchies, geographic borders, or clear jurisdictions. When people have greater access to information, and a much broader, instantaneous ability to communicate, it not only breaks down the lines of control within companies, institutions and governments, it weakens and potentially obliterates the boundaries. It may well change our definitions of communities, the lines between governmental jurisdictions, and the laws, treaties, and policies that define and support them. (12)

Hierarchical knowledge and information transmission structures have been used in schools in a top-down fashion that is frequently antithetical to democratic dialog. Rather than being the primary dispensers of educational content, teachers should supply context and frameworks for the organization and understanding of the abundant content that is now accessible to students working on their own (43). Instead of viewing their role as putting out fires, teachers should adopt a vision of lighting fires of enthusiasm and energy in learners and then facilitating the kindling and burning of students' desire to learn.

Teaching Styles

Teachers and designers of learning hold theories-in-use (44) (improvisational, problem-centered aspects of professional practice) that best describe education under the conditions they most often find themselves teaching. All teachers have implicit or explicit personal theories of what constitues good instruction that describes education under their usual teaching conditions. To learner-centered teachers, part of teaching well is encouraging self-direction and learner control in their students. To do this they use a spectrum of teaching methods. Figure 1 lists selected teaching methods along a continuum from teacher-centered to student-centered (45). I believe teachers will select teaching devices, methods, and techniques and communication/media channels that are consistent with the theoretical basis that they hold, when given the choice.

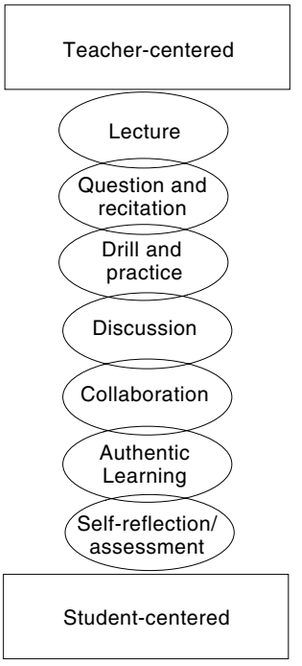

Figure 1. Teaching styles continuum.

Part of teaching using the paradigm of student-centered learning is encouraging and gradually allowing students to assume control of their own learning. Conti suggests that a teacher-centered approach to learning "assumes that learners are passive and that they become active by reacting to stimuli in the environment" (46, p. 81), especially as supplied by the teacher, and that this approach is implemented in the classroom in various ways:

> Learning is defined as a change in behavior. Therefore, acceptable forms of desired behavior are defined in overt and measurable terms in behavioral objectives. Outcomes are often described as competencies which the student must display after completing education activity (46, pp. 81–82).

The relative merit that has been assigned to these changes in behavior has typically been determined by the teacher, acting within the constraints of the educational or training entity's policies, goals, and mission.

In the learner-centered approach, motivation to learn arises as learners attempt to create order in their lives (46). The locus of control moves from the external to the internal (47) and from other- to self-regulatory actions (48–50). Therefore, experiences play a significant role in learning (51). Learners are expected to be proactive and to take more re-

sponsibility for their actions, including their own learning. In the learner-centered classroom, the reality remains that there is still a predetermined body of knowledge and skills that the student is expected to acquire and demonstrate prior to the receipt of the grade or credential, and this may be the student's primary motivation for learning. However, the pedagogical emphasis shifts from just the acquisition and rehearsal of this content to focus on the learners, individually and collectively, and what meaning those learners are constructing during their learning process:

> The central element in a learner-centered approach is trust; while the teacher is always available to help, the teacher trusts students to take responsibility for their own learning. Learning activities are often designed to stress the acquisition of problem-solving skills, to focus on the enhancement of the self-concept, or to foster the development of interpersonal skills. Since learning is a highly personal act, it is best measured by self-evaluation and constructive feedback from the teacher and other learners. (46, pp. 81–82)

The correlate of this notion is that the student will develop trust in the information acquisition and evaluation tools that the teacher models, and in the teacher as an interested guide of the student's learning rather than a disinterested but capricious evaluator with the power to pass judgment of the student's learning experience.

Curriculum

The prevailing curriculum model, often designed along Fordist lines, frequently efficiently organizes subjects within discrete disciplines (e.g., mathematics, science, geography), and then subdivides the content into chunks of tightly sequenced teachable and learnable content—as if teaching/learning tasks were discrete operations to be completed in an assembly-line fashion in specific and discrete time frames. This model assumes that mastery of facts, skills, and solutions acquired while working on each content "operation" performed on each subject/discipline "assembly line" will automatically transfer with the students as they move among different problem-solving operations on different discipline-specific assembly lines.

Unfortunately the student is rarely made aware that the acquisition of an integrated body of knowledge, and a transferable set of information management and evaluation skills is supposed to be the end product of their educational experiences. All too often, because of the design of the curriculum that frames their educational experiences, students fail to transfer useful knowledge from one discipline's "assembly line" to another. For instance, when reminded that they had learned a framework for writing research papers in an English class, students said ". . . but that was English . . . this paper is for electrical engineering." Add to this that the engineering cirricula are structured as an intense presentation of topics in a well-defined order. The use of simulations and student-oriented approaches would not fit easily into this structure (52, p. 29).

Knowledge Chunked and Organized by Experts. Information is typically presented prepackaged and ready-made for students to acquire (53). When the goal is for students to construct their own means, students must collect and access a lot more primary data than in the past (sometimes from their teachers), then sort through, organize, and analyze that information for themselves.

> Textbooks, especially in the sciences, are being replaced in the communication age by direct access to scientific data. During the collision of the Shoemaker-Levy 9 comet with Jupiter in July 1994, students all over the world had access to images and commentaries on this event at the same time that the scientists did. (1)

However, there were experts on hand to comment, point out the implications of the event, and propose various theoretical and analytical frameworks to aid in the organization and meaning, necessitating the use of this mass of raw data as more than a series of colorful visual images.

The "one size fits all" mass production model characterizing the industrial era (40) is giving way to more individualized learning programs and assessment models (54). Rather than controlling learners through a lockstep teaching style, teachers seek to empower students (55,56). Instead of students blindly following procedures written by outside authorities, they can be guided to develop their own and, in so doing, discover the source of knowledge more directly.

Teachers As the Only Audience for Students' Work. Often students must create products or recite information to demonstrate for the teacher's benefit, with the teacher (who already knows more than the student does about the topic) being the only authority or audience for the student's work. This often works against student enthusiasm and motivation to learn because it reinforces the differentials in power and learning that already exist between students and teachers. Communication technology makes it possible for students to increase their audience to include not only their assigned teacher, but other students within and outside their designated learning group, and build a broader learning community (17, p. 64). This can increase significantly the amount and diversity of feedback received by each student and can allow the students access to the knowledge and expertise of their peers.

A Sequential Curriculum. In the not too distant past educators could teach students all they needed to know for what both teachers and learners expected to be their lifelong job. If that were still the case, efficiency and quick transfer of skills and knowledge would usually assume the greatest importance. To the extent we realize that we can not possibly teach students all they will need to know, the acquisition of content set out in curriculum-based goals for education becomes less important than teaching such skills as analysis, synthesis, evaluation, problem solving, and interpersonal communication.

What kind of curriculum is functional in an age of rapid changes? A process-oriented curriculum (e.g., reading, writing, communication, analyzing, synthesizing, evaluating, problem solving, inquiry) yields process skills that hold their value in times of rapid change (57). This does not mean that learning facts and concepts should be abandoned—especially those that have a relatively long shelf life—but the focus should be on using basic knowledge as the building blocks for learning process skills.

Abstractions Separated from Experiential Context. A major force driving organizations to adapt their work processes is the speed of technology change and the extraordinary growth in the knowledge base of most disciplines. Froeschle and An-

derberg (2) state that the skills and knowledge held by an organization's workers are quickly rendered obsolete and so must be constantly refreshed:

> Individuals no longer are assured lifetime careers but rather will cycle between work and retraining in order to achieve a modicum of employment security tied to the evolution of their craft or knowledge base rather than to a particular firm. This has profound implications for education and training institutions because it colors the expectations and demands of the students coming through their doors. (2)

Employers are also putting an increasingly high value on the ability of employees at all organization levels to accept personal responsibility for the solution of more complex and ill-defined problems.

Institutions

The role that technology can play in institutional change has gone unexamined by administrators leading higher education—at least as far as the strategic planning for applying technology to the problems of changing learning and teaching in higher education is concerned (58,59). Unfortunately, those in strategic planning positions may perceive technology only as a series of tools that are the province of technicians at lower organization levels, or typified by the computer or adding machine on an administrative assistant's desk. More attention needs to be given to the increasing use of technology in the institutions' learning support systems, (e.g., library, academic computing, faculty development, bookstore, facilities management).

The use of computer technology for classroom purposes (both place-based and at a distance) is generally brought about by the efforts of individual faculty members, for individual assignments or for use in individual courses, not as an expression of an overall institutional commitment. It will take a major overhaul of higher-education administrators' mental models of the value and use of technology in teaching and learning to engineer the changes necessary to reflect the technological and sociocultural changes in society.

These institutional changes go far beyond freeing up parking, office, and laboratory space because students will be learning at home, at work, and at other locations that will afford them Internet access. Some of the current space taken for classroom purposes may be converted into development and production facilities for multiple-media learning materials. Resources such as laboratories may be scheduled by students for specific uses during specific time periods that may migrate from traditional school hours to evenings, weekends, and time-compressed immersion experiences during vacation. Even so, many institutions may cooperatively arrange exchange agreements for the use of laboratory space at other institutions better equipped for such use or closer to the student. Alternatively, better computer simulations may be developed that may make hands-on, real-life laboratory work a very specialized experience or exclusively for research work (60).

CONCLUSIONS

Our traditional educational institutions are designed on the assumption that all students learn at the same pace and in the same place. The structure of the lecture hall typifies this assumption. It is designed for the rapid and efficient transmission of blocks of sequential information to large groups of students in compressed time frames and assumes an expert at the front of the room and relatively passive learners arranged in fixed rows of seats. While such large groups may be efficient, the sheer number of students involved and the finite number of contact hours precludes discussion between the instructor and many of the students during class time.

Teaching practices in engineering will change to reflect student needs and demands, and through technology acting as a catalyst to more student-oriented teaching and learning. The new curriculum, the changing roles of teachers and students, and the changes in the institutions focus on education will be redesigned toward performance assessment, standards, and accountability (61).

In some ways, the very nature of technologically mediated education, using two-way communication systems, fosters interaction and discussion between student and teacher and among students as peer learners. Seymour Papert states, "the power of computers is not to improve school but to replace it with a different kind of structure" (22). The structure of the technologically mediated environment (i.e., the online classroom) assumes the opposite stance in many important ways. Learning time can be greatly expanded with more opportunity for more students to ask questions and discuss the course material.

Learning need no longer be an activity isolated in classrooms, school buildings, or corporate training rooms where it is physically separate and apart from the rest of a student's world. Technologically mediated online learning can occur where students can lift their eyes from their monitors (e.g., computer or television) and see their homes, their offices, or other familiar spaces around them—schooling has entered students' life spaces. Motivation is often high because students are encouraged and free to self-direct, or at least codirect, their learning, rather than the instructor initiating and pacing activities.

Is there still a place for a Fordist education model? Some aspects may remain viable. After all, the industrial revolution did not replace farming, but it changed the way in which farming is done. Mechanization has reduced the number of farmers needed to feed the population from 85% of the workforce to less than 2% within a century (62). Still, there is a critical need for those 2% who plant and harvest. Many products are assembled efficiently and inexpensively on the Fordist production lines that replaced more costly individual craftsmanship, making more products available to more people. As technology has been a catalyst for changes in farming and production, so it has become a catalyst for change in education.

We cannot imagine the completeness of changes to come—even though they will come. In many ways, the engineering curriculum, the models of pedagogy used, the support given to students, and the way we manage the learning environment signal changes to the culture of higher education at a pace so quick and a context so complex that we can not see the end from when and where we begin the journey. Like the empty factories in the rust belt, the emptiness of our traditional institution of education will not please everyone. The gravest challenge for educators in the Communication Age

may be to find better ways to plant the seeds in students that lead them to a harvest of greater knowledge.

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