CONTINUING EDUCATION

One of the outstanding engineering educators of all time, William L. Everitt, former Dean of Engineering at the University of Illinois, often said, "Engineering is not a learned profession, it is a learning profession." This statement captures the essence of this article, which discusses the need for engineers to continue to learn throughout their professional careers, and discusses some of the ways engineers find useful to engage in this pursuit. The need has existed for a long time, and engineers have utilized the best available technologies and techniques to meet the need. The importance of continuing education continues to increase as the pace of technological change increases, and as more knowledge is available and used. The focus of this article will be on programs designed by industry, government, and the university.

DEFINING CONTINUING EDUCATION

In its most general sense, the phrase *continuing education* usually refers to a formal program of post-baccalaureate-degree education established for the purpose of maintaining and enhancing knowledge and skills. Often there is a connotation of a job-related activity. The program may lead to a graduate or professional degree, or it may lead to a certificate of accomplishment or attainment. It may be part of a legal requirement to maintain a license in a profession. The outcome may be personal satisfaction. The program may last for a few hours or for several years. The term "continuing education" is extremely broad, and so are the ways in which engineers accomplish the goals of continuing education. There are, however, some related terms that help clarify the ideas. Many of the terms have connotations that are significant to the user.

Some universities are now using the phrase *extended education* to describe continuing education activities that are designed to enable engineers to earn post-baccalaureate degrees on a part-time basis while fully employed in industry or government. This term is an attempt to distinguish between types of activity within the university, but at present it does not seem to have widespread acceptance. A closely related term is *lifelong learning*. This latter phrase applies to an individual who engages in continuing education, so that the term describes the participation more than the process.

NEED FOR CONTINUING EDUCATION

Engineers, indeed practitioners of all professions, have always sought better ways for accomplishing their goals. They seek to improve performance, efficiency, reliability, and aesthetics, and to reduce costs. Where possible they share ideas. They envision new ways to improve the quality of life for people. They perform research and try new ideas continually. In short, they learn from each other in discussions, in classes, at conferences, by reading, and in formal programs designed for this purpose.

While the need for continuing education has always existed, it takes on increasing importance in today's world. It is generally agreed that knowledge is ever increasing, and that the challenge of keeping abreast of changes, while at the same time evaluating the information available, poses a significant challenge to everyone. Today's engineer must be aware of changes in the practice of engineering close to her or his field, and must be aware of changes away from this field, as engineering is becoming more interdisciplinary. Formal programs and self-discipline are required for engineers to be able to maintain and enhance a high level of competence in the profession. There is another reason for continuing education. Nearly all engineers simply want to continue learning all of their lives, both within their profession and for personal self-satisfaction. To achieve the latter, reading is necessary, but often formal programs are needed for effective learning.

TOPICS FOR DISCUSSION

This article will discuss several topics that are closely related to continuing education. The first important topic will be graduate study in engineering. Graduate study is a domain entirely of the universities, but may take place either on or far away from the campus. If the students are located away from the university, then some form of distant education technology is involved, and this topic is discussed. Continuing education programs offered with a goal of advanced learning, often with certificates but not formal degrees, are offered by a wide variety of agencies, and these are discussed. Finally, some of the terms frequently used by engineering educators, especially those involved in some form of continuing education, are discussed.

GRADUATE STUDY

What Is Graduate Study?

The phrase *graduate study* refers to formal educational programs offered by universities that provide additional study and degree programs beyond the baccalaureate (bachelors) degree programs. These programs have two major foci, though the dividing lines between the two are not rigorously drawn.

First, the primary purpose of graduate study traditionally has been to prepare students for careers in research in their respective disciplines, though of course not all recipients have pursued such careers. Typically programs include study of a discipline at an advanced level, high-level study in closely related disciplines, and preparation of a thesis or dissertation. The latter is invariably documentation of an independent, though carefully guided, research effort by the candidate. Not only must it be defended within the university, but significant parts of it must normally be submitted for publication in peer-reviewed professional journals as well. The highest level of these degrees is almost always called *Doctor of Philosophy* (*Ph.D.*). The degree intermediate between the Ph.D. and the baccalaureate degree is usually the *Master of Science* (*M.S.*) degree. Often, but not always, the M.S. also requires preparation of a thesis.

A second type of post-baccalaureate graduate study leads to a *professional degree*. In a few cases, these may be bachelors degrees, for example, Bachelor of Engineering or equivalent, but more common titles, in engineering, are Master of Engineering, Doctor of Science, or Doctor of Engineering. A professional degree is no less rigorous than the more common research degree, but the focus is different. The research project becomes a major development project, leading to a significant advance in an engineering application, though not necessarily basic research in engineering. Publication is less important; projects and products are more important.

As a recipient of either of these degree types matures and contributes, the distinction between the types of degree diminishes. Because both programs tend to emphasize high quality, creativity, originality, and rigor, the similarities are more important than the differences.

Graduate Study in the United States

Graduate degree programs in the United States and in most of the world serve several important functions. One is to provide degree programs for students who want to continue their education beyond the bachelors degree, in order to prepare for careers in research, in universities, and in high-level advanced development. Another is to provide programs in which senior research scholars are able to enhance their research by attracting students who, in addition to studying in a formal sense of the word, also serve as research assistants. In this capacity they learn to do research by actually working under the close supervision of an established scholar. The faculty members who teach the advanced, graduate-level courses gain in another important way. They remain involved at the leading edge of developments in their disciplines, and continually evaluate current journal articles and products for their students. They involve their students. Many outstanding graduate-level instructors take their students to a knowledge frontier during each class period, and help them survey the scenes for future ideas. In this way, teaching graduate-level courses is actually a form of continuing education. Each idea is discussed further in the following paragraphs.

The engineering profession is an old one. Until the nineteenth century, however, nearly all of the practitioners of engineering learned as apprentices rather than as students. Engineering advanced empirically in virtually every aspect. The interaction between the scientist and the engineer was minimal. Today, however, the scientist and the engineer interact on a regular basis, to the mutual advantage of both. Individuals now move freely in both directions over the vaguely defined boundary between science and engineering. Engineering advances today are almost always based in basic sciences and modern information technology and have a firm theoretical foundation. This fact alone is a major reason for the rapid advance of knowledge all seen today. This fact also leads to the need for graduate study.

Engineers who want to do research or advanced development, either in a university, in a government laboratory, or in industry, now find it necessary to have an education that is firmly grounded in basic science, mathematics, and the information sciences. Such an education simply cannot be gained in a four-year baccalaureate program. Engineers whose primary motivation is teaching also find such an education absolutely necessary. Virtually all universities require their faculty members to have earned a Ph.D. degree before being employed as regular faculty members. They further require that their faculty continually use and extend their knowledge, whether strictly as research or in related forms.

Engineering research is now a team effort. The projects are usually large and require the talents and ideas of many people. Engineering research in a university setting is usually characterized by group leaders who are senior faculty members, less-senior faculty working on closely related projects, and graduate students, who are commonly called research assistants (RAs). The RA is an important part of the team. The RA typically performs the research needed for a thesis or dissertation in this setting, and the RA's work serves to advance the knowledge produced within the group to the benefit of all. The RA learns to research by doing it, and eventually becomes a research leader, whether in government, industry, or a university. The process is occasionally criticized as a "cloning" operation. Those who disagree with this criticism point out that it has led to a world-wide rapid expansion of knowledge and a concomitant expansion in the quality of life for many people.

Engineering educators regularly state well-founded opinions that continuing education is necessary for engineers in government and industry. Continuing education is also necessary for engineering educators. Some of the common characteristics of a person who has completed advanced degrees are a thirst for knowledge and the willingness, self-discipline, and ability to continue learning throughout a lifetime. Knowledge expands so rapidly that relatively little of what the engineer teaches is material studied as an undergraduate or, for that matter, as a graduate student. When one knows how to do research and how to continue learning, doing it is a feasible and realistic expectation for all concerned.

An important conclusion that one can draw from comparing the expansion of knowledge in engineering with the expansion in both the number and quality of engineering graduate programs in the United States and around the world is that there is a close correlation between the two activities, which has served the profession and society well.

Graduate Study as Continuing Education

The education that is offered to students seeking to earn advanced degrees is usually appropriate for engineers in industry who want to continue their studies. The relationship between engineers in industry and their managers has a major influence on how programs develop. Some companies encourage, even require, their engineers to pursue masters degrees on a part-time basis. Other companies encourage their engineers to take specific courses in order to gain enhanced knowledge, though there is no major incentive for those engineers to earn advanced degrees. In both cases, a major motivation for the engineer is to increase individual educational level, which is also the goal of continuing education programs in general.

Universities around the country have worked closely with industry to provide these opportunities. The techniques vary, but all have the common feature of a highly qualified faculty, usually regular but occasionally adjunct, presenting the courses to engineers in appropriate formats. Faculty members have ridden on trains, driven cars, and flown in university aircraft to industrial sites. In some cases engineers have come to the campus, though today this is less common. Large industries located near major universities have built special educational facilities. More recently, television is being used. The process of televised education is discussed later, in the section titled "Distance Education."

Some universities do not distinguish between the degrees earned by on- and off-campus students, whereas others use different names for the degrees the two groups of students earn.

Engineers in industry who are students in these programs have important needs that must be considered. One question for the faculty to consider is whether or not to require a thesis. The students might like to write a thesis on a work-related topic, but this desire often leads to proprietary concerns. A thesis is a contribution to the public domain, which conflicts with industry's need for protection of its trade secrets. Two solutions to this concern are to have degrees conferred solely on the basis of the completion of course work, or to replace the thesis requirement with a project requirement. The advantage of a project is that it is not in the public domain, yet it can be held to standards comparable with those of the thesis. Typically the project is advanced development vis-à-vis research. The disadvantage of these solutions is that, should the recipient later decide to pursue a Ph.D., credit for the earlier work may be deflated or even denied. The combination of these pressures and concerns is a major factor in the mixture of types of masters degrees mentioned earlier.

An important program that is meeting the needs of students in industry is offered by the National Technological University (NTU). (1). The NTU is a consortium of approximately 50 major universities across the United States that supply their graduate courses to engineers in industry. (The delivery method is discussed in the "Distance Education" section.) NTU serves a number of major functions in this masters degree program: It grants the degrees and it serves as a broker or "clearinghouse" to select courses and make them available. The universities themselves both cooperate and compete in this process. They compete with each other in order to get their courses listed in the catalog and offered on the network, but they also cooperate in order to have comparable standards, to compile logical selections of courses, to advise students, and to see to the other details that are essential to presenting a good degree program. The degree offered by the NTU is a Master of Science (without thesis, though the option of writing a thesis exists).

With few exceptions, universities find these educational programs made available to industry to be valuable. They frequently lead to industry-sponsored research contracts. They may lead to consulting and other work relationships between industry and the faculty. They may open opportunities for undergraduates to enroll in cooperative programs. Obtaining information on these programs has become quite easy with the rapid development of the World Wide Web. The Bibliography gives addresses for a few of the more than 50 universities offering such programs (2).

CONTINUING EDUCATION PROGRAMS

A strict but not universally accepted use of the phrase *continuing education* refers to programs designed to give students additional knowledge, but not intended to lead to degrees.

The phrase *short courses* often describes the activity. Continuing education programs are offered by many institutions. These include universities, industries, vendors, professional societies, and educational institutions founded for the primary purpose of providing continuing education events for engineers and other professional people. The programs may lead to certificates of completion, continuing education units (CEUs) (3), or the knowledge the participant needs to accomplish a needed task. Many licensing agencies require licensed professionals to earn CEUs or equivalent before license renewal. The lines between these types of programs are not distinct. One program that has attracted engineers for 25 years or more is the University of Wisconsin Professional Development Program (4).

Many universities offer continuing education events in conjunction with their degree programs, while others concentrate primarily on short courses. The faculty for the short courses may be the regular university faculty, or may be outside experts brought in for that purpose. Often the faculty is a mixture of these two types. The short courses are almost always carefully planned, they present material that is very up-to-date, and they are practically oriented. Students in these courses tend to be, in a good sense of the word, demanding. They have high expectations for rapid, effective learning. Students tend to return to universities that present outstanding short courses. Not all short courses are presented on-site at the university. Many are taken to the industrial sites, and some are taken to convenient, attractive venues in various parts of the country.

Industries themselves organize and present short courses for their own employees. The topics may be proprietary in nature, so that the industry does not find it necessary to release data on new products to people outside the company. The topics may be concerned with new information that has not yet made its way to the universities or to other sources. The topics may be company specific, such as studies of company management systems or changes in manufacturing methods. Many companies find these programs to be somewhat more expensive than courses provided by outside agencies, so that they use them only when necessary. Others find them to be cost and educationally effective.

Vendors often provide short courses for their new products and services. In some cases, these are offered at nominal cost to the participants, but in other cases, they are quite expensive. These courses train people to use new equipment and software, so that the users have the knowledge needed to enhance their own job performance. Sometimes these programs lead to certifications for new skills for engineers and other technical people who operate as independent consultants. An example might be the programs used by several computer networking companies to train installers and maintenance personnel for their networks.

Professional societies, such as the Institute of Electrical and Electronics Engineers (IEEE) (5), frequently include short courses in the programs for their conferences, often at the beginning or the end of the conference (the reason for this is that the short courses tend to be longer than typical conference sessions). Nominal extra fees are usually charged, and the courses are generally presented by outstanding scholars and presenters who are closely associated with the conference itself. These conferences are particularly effective venues of learning for many people. Professional societies, such as IEEE, also may produce home study courses for their members. As delivery tools these courses use a mixture of videotapes, computer disks, and books for the engineer. CEUs may be awarded for participation in these activities.

Professional societies play another important role in continuing education. In the United States, this is exemplified by the American Society for Engineering Education (ASEE), especially its Continuing Professional Development (CPD) Division (6). Other organizations include the International Association for Continuing Engineering Education (IACEE) (7), with headquarters in Finland, and the International Association for Continuing Education and Training (IACET) (3). These organizations bring together educators in industry, government, and universities. These people together study the needs for continuing education, do research in effective techniques, publish results, hold conferences, and provide all concerned with research-based knowledge in effective techniques for continuing education. Two important documents published by the CPD Division of ASEE are listed in the bibliography (8,9).

Another type of institution that provides continuing education is a company organized for just this purpose. These companies tend to compete with universities. They serve industry by making all of the arrangements for company courses, whether on company premises or at convenient locations. They present short courses at professional conferences. Because of the high expectations of both industry and students, these companies find that they must provide high-quality presentations of state-of-the-art material.

The National Technological University (1) has an extensive short-course program in addition to its degree program. The courses are delivered from a variety of sources around the world, and are available by subscription to participating industries and universities around the country.

Some universities have found it desirable to produce high-quality videotapes to meet some types of continuing education needs. Some 35 of these universities have banded together to form a marketing organization for such tapes. It is known as the Association for Media-Based Continuing Engineering Education (AMCEE) (10). Closely related to this is the Web site maintained by the International Association for Continuing Engineering Education (IACEE) (7).

DISTANCE EDUCATION

The phrase *distance education* has arisen in the past few years to describe a long-standing process. The phrase describes the situation in which students and instructors are geographically separated, and it has also been used to describe the situation in which students and instructors are separated in time, though proximate in location. This is reasonable, as the characteristics of education when instructor and student are separated by space or by time have much in common. The relation of the concept of distant education to continuing education, whether in the narrow or broad sense, is that the process of distance education is being heavily used to enable continuing education. Distance education is also being used for undergraduate education and for K–12 education, though these uses are not a focus of this article.

Early forms of distance education include correspondence courses or involved travel by the instructors, who used the best available transportation methods. The archives of land grant universities include pictures of engineering faculty riding trains to teach engineers the latest techniques for road construction or electric power installations. In the 1950s and 1960s, faculty switched to cars and airplanes as they traveled to meet with their students. These techniques are still used, but in the late 1960s, engineering faculty began to experiment with the use of television in a variety of forms, in order to effectively and economically give their students the education they wanted. The experiments were successful, and today several forms of television play a major role in graduate education and in short courses. Today engineering faculty members are experimenting with use of the World Wide Web in continuing education, either in conjunction with television or as a totally new technique.

Synchronous and Asynchronous Delivery

A useful classification of distance education techniques is to consider whether they are *synchronous* or *asynchronous.* Some add an intermediate classification of *semisynchronous* or *partially synchronous.* A synchronous method is one in which the students and the faculty are in full, two-way communication throughout the educational event. The students in the distant class may ask questions and, what is most important, all proceed at the same pace, usually set by the faculty member. Ideally there is a lot of student-to-student interaction. In addition to in-class interaction, students and faculty may interact by e-mail, telephone, facsimile, and other techniques, so that there is as much interaction in a distance education students class as in a conventional class.

An asynchronous method is one in which students set their own paces, within limits, and student-to-teacher interaction occurs when needed by either party. Students work at different speeds, with the requirement being that all finish by the specified deadline. There is little if any student-to-student interaction, and none is expected except when there is a group of students at the distant site. Student-to-faculty interaction is entirely by e-mail, facsimile, and telephone.

Semisynchronous techniques have some of the characteristics of synchronous systems. All students proceed at the same pace, and usually, though not always, there is considerable student-to-student interaction. The distinction is that the students are receiving the learning at a time different from the instructor's presentation and, if there are several groups of students enrolled in the same class, the various groups receive the learning at different times. The delay is virtually constant throughout the learning period. Students in individual groups interact readily, but not with students in other groups. Student-to-faculty interaction again takes place by e-mail, telephone, and facsimile, but because additional presentations are likely, one student's question can serve to give instructors ideas to present to all students.

Synchronous and semisynchronous techniques usually have the characteristic that the faculty is presenting material to a group of students on the university main campus, while at the same time presenting to distance education students. Asynchronous presentations may or may not have an on-campus student group.

Television and Continuing Education

Television links students and faculty in a variety of ways. Each has advantages and disadvantages, and thus adherents and critics. The early systems would today be described as semisynchronous. They used videotape in sparsely populated areas, and microwave links in heavily populated areas. Satellite systems appeared at this time. The first videotape uses were reported by Colorado State University and by Iowa State University, beginning in 1969. Microwave links were reported in Texas, Florida, and California at about the same time. The cameras were black-and-white, large, and intrusive in the classrooms. They inhibited on-campus students, especially from asking questions in class, but the off-campus students were eager to get the knowledge, and so accepted the system and quickly helped to guide its improvements. Both videotape and microwave transmission continue to be important today, though improvements in equipment have led to studio classrooms that combine television equipment and computers in ways that really enhance the instructor's capability to present material. Stone (8) studied the performance of graduate engineering students in televised class at about 10 major universities, and concluded that those students who were seriously pursuing advanced degrees performed as well as and, in many cases, slightly better than the on-campus students.

An early change made to microwave broadcasting was to add audio feedback from students to the instructor by providing a telephone callback feature. This makes the system synchronous, provided the students at the receiving site view the broadcast at the same time as the class is being transmitted. Often the students desire the time-shifting that videotape provides, so they record the class and watch the tape at a more convenient time. This also presents great advantages when the engineers in industry must be in transit. In practice, most instructors report little use of the callback feature. One important reason for this is the fact that in these modes there is usually a group of students on campus, and more and more they have become willing to ask questions in class, usually very similar to those the off-campus students would like to ask. Since the questions are recorded, all students benefit from the responses.

The National Technological University

In 1984, the National Technological University (NTU) (1,11) began using satellite delivery of graduate courses transmitted from more than 20 universities around the country. In due course each university had its own transmitter, so that a larger population could be addressed, and the students in industry around the country had the potential to receive classes as they were being presented on the university campus. By the late 1990s, NTU had nearly 50 member universities, 900 participating company sites, was broadcasting some 200 courses per academic term, and awarding more than 200 masters degrees annually. In most cases, the system is best described as semisynchronous because of the fact that, while substantial student-to-faculty interaction occurs, it does not occur during the broadcast time. If, say, students at ten or more receiving sites were to try to contact the instructor in the class period, then keeping a class going could become quite a challenge. Student surveys indicate that the majority of students record the classes for viewing at a convenient time. In addition to its credit courses and degree programs, the NTU also broadcasts several thousand hours per year of continuing education events.

In the United States, NTU is the first "virtual university," an institution that is not located in one specific place, but is available to students anywhere provided they have the technological equipment needed to receive the knowledge. (In the United Kingdom, the Open University began in the 1970s.) As this is written (1998), NTU grants degrees in 12 disciplines: Aerospace Engineering, Chemical Engineering, Computer Engineering, Computer Science, Electrical Engineering, Engineering Management, Hazardous Waste Management, Health Physics, International MBA, Material Science and Engineering, Manufacturing Engineering, and Software Engineering. It also has a Special Majors program.

Two-Way Audio and Video Systems

In many situations, instructors and students alike wish to have real-time, two-way interaction during the class presentation. Such interaction appears to be more important in classes that require a lot of discussion, such as those in which case studies and active or cooperative learning play an important role, and in classes presented to undergraduates. The importance of real-time interaction certainly depends on the instructor's style, the content, and the characteristics of the students. Major developments have made such programs possible, and the capability is achieved in a variety of ways. In this section, discussion is limited to systems that permit two-way audio and video interactions.

In principle, any one-way system can be converted to a two-way system by simply duplicating facilities, thereby providing a communications channel in each direction. This nearly doubles the cost, but works well from a technical standpoint when the instructor is in contact with one or a very small number of student groups. Two-way microwave links, which are typically links between a university and a single industry, work well, and are found in many locations. Two-way satellite links work well when used between one instructor and one or a small number of student groups, but in practice are rarely implemented because of cost and technical complexity.

A practical two-way audio/visual system (full duplex system) is provided by *video-conferencing.* This system uses digitally compressed video signals that may be transmitted over high-grade telephone lines, including the various microwave and satellite links that are included. The systems permit full duplex operation between students in one group and an instructor at a distant site. With suitable switching, more than one student group is possible.

The Iowa Communications Network

The State of Iowa has built what is probably the most extensive network for distance education in the United States. The state is nearing completion of a set of more than 800 facilities equipped for full duplex television with central switching, so that one transmitting site can send to as many sites as desired. The connection medium is fiber optic cable. The network was originally conceived as being appropriate for enabling smaller, more remote high schools to join with larger schools for advanced instruction in such topics as foreign languages and advanced mathematics. Because of its great capability and flexibility, however, it is being used more widely for distance education. Courses in all disciplines, including engineering (12,13), are being exchanged between universities, between universities and community colleges, and from universities and community colleges to libraries, hospitals, National Guard armories, and public schools. Ways for connecting this network to systems in adjoining states are being developed. Many states, including North Carolina and Indiana, have networks that connect a variety of institutions. More will undoubtedly be developed in the future.

Television and the World Wide Web

The idea of transmitting full-motion television over the World Wide Web (WWW) attracts research and development. Already televised images are transmitted, but the quality in general is, so far, inadequate for educational purposes. This will change in the near future, as the bandwidth of the internet increases and compression techniques are further developed. The opportunities that this capability will provide will be virtually unlimited, and distance education involving the entire world is a likely result.

World Wide Web and Internet Courses

The advent of the WWW has challenged educators to find ways to use it for distance education. Many universities have active development groups working on courses in computer programming, mathematics, biology, climatology, history, electric circuits, and many other topics. Some use the WWW to deliver materials to students regardless of location, while others are programmed so that the students interact with the subject matter on the Web, taking "mini-tests," asking questions, and moving through the material as needed to learn effectively. Some use audio, while others depend entirely on visual images. Short segments of video are included, and still images are a major part of the attractiveness of the technique. The technique is growing so rapidly that students can or soon will be able to find educational material, either continuing education or credit courses, on almost any subject of interest.

Issues and Concerns in Distance Education

Distance education courses raise some interesting concerns. Students must be attracted and their qualifications evaluated. One technique for WWW courses is to allow students to take one or two of the beginning parts of a course in order to evaluate both the technique and the specific content. After that, the student must formally register and gain access to the course content and credit for completing the course only under control of a password or similar security provision. The same password is needed for testing, along with a password from a proctor, whose responsibility it is to ensure that the student taking the exam is the one actually registered. Some early experiments of controlling experiments on the WWW have been reported. These are not simulations but actual experimental apparatuses that would always be computer controlled, but are now controlled at a distance (14).

When they are being graded and earning credits toward a degree, students want to be able to interact with an instructor in a flexible, economical, and effective manner. Students in continuing education events also have a similar desire. In these situations, students interact with instructors via electronic mail, facsimile, telephone, and over the WWW. These development projects are greatly expanding the capability and responsibility of the faculty in engineering and in all disciplines, and the challenges and opportunities are very significant.

Another significant issue is the faculty reward system. Developing such a learning experience requires creative scholarship and a lot of hard work, but these alone do not qualify the work for typical faculty rewards such as promotion and tenure. Televised and WWW courses do provide one important feature, in that they project the faculty member beyond the campus, so that the faculty member potentially has impact across the country and around the world. There are also questions of financial rewards for such activity, especially of how to compensate the faculty member over time.

The issue of copyright is an important though not fully resolved one. Who owns the copyright to material on the WWW, and how is this protected? Who owns copyright of videotapes that are produced and then copied at a receiving site? These issues have generated a lot of discussion and opinion pieces. Reasonably effective solutions are in place for most of the televised material, as agreements consistent with the laws and also the policies of the universities can be written in advance, but more research and legislation is needed for WWW activities.

Another issue is that of cooperative learning (see EDUCATIONAL TRENDS). Engineering faculty members are finding that presenting classes using advanced techniques of a cooperative and guided active learning greatly increase their effectiveness as well as learning on the parts of students. Extending these techniques to distant education is a challenge most easily accomplished in fully synchronous modes. Cooperative learning in semisynchronous and asynchronous modes is a topic just beginning to be studied.

Degree Programs and Nontraditional Students

The phrase *nontraditional student* is a loosely used term to describe students who are older than the typical student found on a university campus. Some of the characteristics of nontraditional students are that they are older, perhaps 24 to 40 years old, employed, have family and community responsibilities, and want or need additional education, either for personal growth and satisfaction or for job-related reasons, such as job security and advancement within the company. While for some of these people short courses are sufficient, others want degree programs, and they are willing to do the work and spend the time (12). The demands for providing high quality undergraduate programs present some challenging problems. A typical masters degree requires 30 to 36 semester hours, or 10 to 12 courses of three credits each. At a rate of three courses per year, a student earns a degree in four years. Accelerated programs, sometimes called *executive programs,* may be completed in two years. However, a typical baccalaureate program requires 120 to 128 semester hours. At 15 to 16 hours per year, an eight-year commitment is needed, and a longer commitment is almost always going to be necessary.

Many universities in larger metropolitan areas have met this need for years with evening programs, and they have been quite successful. In lesser populated areas, however, evening programs do not work, and so distant education is meeting this need. As with evening programs, some universities will award graduates exactly the same degree as the on-campus student receives, while others create special degree designations.

CAREER DEVELOPMENT AND LIFELONG LEARNING

Industry 2000 Conference and Career Development

Continuing education is certainly a fact of life in the modern world. Engineers find continuing education necessary both for personal growth and satisfaction, and for reasons that may be described as *career enhancement* or *career development.* In 1994, the Institute of Electrical and Electronics Engineers (IEEE) held a very significant conference devoted to this topic. The conference venue was Denver, Colorado, and approximately 100 people from engineering groups in industry, continuing education operations in industry, and universities attended. The conference theme was *Technical Vitality Through Continuing Education.* A conference Proceedings was published (15). The conclusions of this conference substantiate those of other conferences and studies, but this conference brought together people with knowledge, experience, and vision, and synthesized ideas and actions from a wide variety of sources. Thus it is a rich source of knowledge and ideas on which to base future actions. The conclusions of this conference are presented extensively here.

Challenges of Advancing Technology. One important question considered was that of how engineers and their employers should face the challenges of advancing technology, the competencies needed, and how to get the necessary education and training. Those present recognized that both employers and engineers (employees) have a responsibility here. As professionals, engineers have long had a major responsibility for their own careers, and this will increase. Some of the reasons for this increase are the world-wide nature of engineering practice today, and the fact that highly talented engineers are found around the world. Another is the trend in some industries to employ more outside consultants and thus to have fewer engineers on their staffs. Engineers will be evaluated more for their capability than for their knowledge, more for their ability to work in teams and to think, work, and produce in a systems context, and will be expected to work and produce in a process orientation vis-à-vis a product orientation. Engineers must keep themselves "lifetime employable."

The responsibility for professional development is not limited to the engineer. Employers have a responsibility, especially to people employed by the employer for a substantial time. These people have talent and experience, but they can also cause employers major problems if regular professional development does not occur. Time must be made available by the employer, and the employer must make such an activity an expectation or job requirement. The employer must view continuing education as an investment, not as an expense. The employer must link continuing education for its professional employees to long-term company goals.

Hindrances to Technical Vitality. An important concern in continuing education programs is to identify hindrances to maintaining vitality. Industry 2000 participants considered this question, and identified eight factors to address. They apply to engineers and employers alike and, in order of importance, are:

1. Availability of time
2. Lack of motivation

3. Inability to justify a return on investment
4. Inaccessibility
5. Lack of resources
6. Lack of a plan
7. Quality of materials
8. Organizational culture

The time problem has been discussed earlier in this article. The engineer may deal with pressure from the job at hand and from home and family responsibility. Continuing education usually has a long-term focus and therefore is easily delayed. Closely related is the issue of motivation. In general, both the individual and the company must be motivated for effective continuing education to occur. Engineers and companies that see continuing education as an expense will seek to minimize it, while those seeing it as an investment will seek to maximize their return over a reasonable period. All of these factors are manifestations of the corporate or organizational culture being considered.

To be effective, continuing education must be convenient. This is especially true of short courses, which optimally will come to the work site and, in the future, must come to the desktop. The material must be high quality, sharply focused, and tailored to the audience. The course must be affordable and must fit in with the plans of the engineer and the employer. Probably the important factor is that the leaders of the organization must set examples for their employees by engaging in continuing education themselves.

Essential Principles for Success. The conference defined success as having a technically vital organization. The first principle was important work—work that makes a difference and generates good reputations among peers. A second, which repeats a point from a previous section, is the personal example set by the management. The third is a customer focus—maintaining contact with customers and being sure that the products and processes being developed are what the customers want and need. The fourth is establishing and clarifying a link between business success and technical vitality.

Ideal Continuing Education Scenarios. The conference attendees took a general, long-range view of the question of what constitutes ideal continuing education or career-long professional development. The scenario is more a question of what constitutes an effective program than of immediate delivery and content questions, though those were considered also. There is a need for interdisciplinary efforts, as well as for sharply focused events. Interdisciplinary ideas include a range of engineering topics, as well as business topics such as marketing and globalization.

Regardless of topic, programs must be short, and well designed by recognized experts, both in content and in delivery. The programs must meet perceived needs and be relevant. They must be tailored to the abilities of the learner, and be cognizant of the learner's previous background. Education for needed knowledge must be linked to project planning. If the provider is a university or other outside agent, then the planning must involve both, with due regard to issues of ownership of intellectual property, short life cycles of materials, and the rigidity of university calendars. Finally, the programs must be cost effective, even when viewed as investments. Both employer and employee must see the programs as having a favorable cost–benefit ratio.

Professional Society Recommendations. The Industry 2000 conference was organized by the IEEE. It addressed the question of what the IEEE should be doing for its members with respect to continuing education. The conclusions came in the form of four principal recommendations, and IEEE is implementing these recommendations for its members (5) (presumably similar conclusions would apply to other professional societies). They are:

1. The IEEE should develop a set of career planning tools for use by each member.
2. The IEEE should develop a centralized database of continuing education materials, which informs all members about the opportunities available to them.
3. The IEEE should establish and support a forum for "Best Practices" in continuing education.
4. The IEEE should explore appropriate measures for recognizing participation by engineers in lifelong learning.

For each engineer, a career plan is essential. The plan should help the engineer define success and the values and behaviors that lead to success. It should then lead to a set of goals and the projects to accomplish the goals. It should raise awareness about emerging technologies, in the broadest sense of the term. A lot of continuing education material is available from a wide variety of sources, but it is not always easy to find out what is available or, what is more important, where the material might be that meets a particular need. There is a need for some evaluation of this material.

Both engineers and employers need to know how to perform continuing education effectively. There is need for sharing ideas, though there is no more incentive for a company to share its practices than its knowledge. There is a role for professional societies in this regard. Finally, there is very little way to formally recognize continuing education, as discussed earlier in this article. A meaningful measure established by one society would slowly but surely win acceptance across the profession.

Conference Conclusions. The conference conclusions are of value. Some are ideas that have been around for a long time. Others are quite new. They are:

1. Engineers have a personal responsibility to maintain their own technical vitality, but they must be supported by their employers in this endeavor.
2. It is especially important to focus on continuing education during business cycle expansions. While time is short then, the pressures during recessionary cycles are more severe. Also, such training can enhance competitiveness during expansion periods and may mitigate future down cycles.
3. There is substantial correlation between company size and continuing education effectiveness, with the larger companies being more effective.
4. Senior management must be committed to and engaged in continuing education.

5. Tools for assessing the quality of continuing education and plans for continuing education are needed.
6. Colleges of engineering need to do a better job of convincing undergraduates of their forthcoming need for continuing education. Interestingly, this recognition across the profession has led to an accreditation criterion that will be discussed in the next section, Lifelong Learning.
7. Evaluation criteria for nonuniversity courses are needed.
8. The IEEE should elevate the visibility and effectiveness of its continuing education activities.

Lifelong Learning

In the United States, engineering programs are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. New criteria based on outcomes assessment techniques have been developed and are being implemented, with full implementation scheduled for the year 2001 (16). One criterion states that graduates of an accredited engineering program *must demonstrate that their graduates have a recognition of the need for and the ability to engage in lifelong learning* (Criterion 4.i) (16). Lifelong learning is the result of effective continuing education, both the interest in doing it and actually accomplishing it. Faculty members in colleges of engineering across the country are trying to design learning experiences for undergraduates that will develop lifelong learning skills and attitudes in students. Lifelong learning is also an expectation for faculty members. The accreditation criteria also have a requirement for professional development of the faculty.

Continuing Education Resources

The engineer who is seeking continuing education will find a wide variety of opportunities. These resources may be found by contacting education and training offices of employers, who usually have a lot of information available. Often these people know who provides good opportunities and can assist the engineer in finding programs to meet needs. Most engineers belong to at least one of the more than 50 engineering professional societies in the United States alone, such as IEEE and the American Society for Mechanical Engineers. Nearly all of these societies present programs related to their specialty. A telephone call, e-mail message, or World Wide Web (WWW) search will provide the needed information.

Many of the approximately 400 colleges of engineering in the United States provide continuing education events, both degree programs and short courses. The distance education technologies described make distance a minor factor in choice, so that the student can choose based on subject matter and reputation of the provider. Again, finding the information is relatively easy. The bibliography lists 10 such university sites (2), and search engines lead to many more.

Data show, however, that the programs are quite variable in many respects, and finding good evaluations of the programs is difficult. The person who wants continuing education needs to put effort into evaluating the opportunities. The student should carefully consider the reputation of the offering institution and of the faculty who present the material. The material must be up to date. This is true for all events, but especially for the short courses. The student should consider price, availability of written materials and computer software, access to the instructor, location of the events (when travel is required), and teaching styles of the faculty. Many courses are presented on videotapes and the student is advised to obtain a sample tape for, usually, a two-week evaluation at minimum cost. Are CEUs available, and needed? Many licensing agencies require CEUs. Time and effort spent in evaluating the opportunities will pay big dividends to the student.

CONCLUSION

Lifelong learning is an essential activity for engineers today and continuing education methods enable lifelong learning. Continuing education includes programs that are based in academic credit and that usually lead to university degrees as well as noncredit or short courses that are targeted toward particular knowledge that usually has an immediate application on the part of the recipient. Continuing education for engineers is an important part of the practice of engineering in the United States and around the world today.

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2. Introductory or home page World Wide Web addresses for a few of the more than 50 colleges of engineering that offer graduate degrees in engineering in the United States are:
   a. The Johns Hopkins University: http://www/jhu.edu/~wse1
   b. Stanford University: http://www.stanford.edu/home/academics/continuing.html
   c. University of Wisconsin: http://www.engr.wisc.edu/general/depts.html
   d. Iowa State University: http://www.eng.iastate.edu/ede/homepage.html
   e. Purdue University: http://www.ecn.purdue.edu/cee
   f. University of Illinois at Urbana–Champaign: http://www.conted.ceps.uiuc.edu
   g. George Washington University: http://www/gwu.edu/~ceep
   h. University of Southern California: http://www.usc.edu
   i. University of California at Los Angeles: http://www.ucla.edu
   j. University of Minnesota: http://www.technology.umn.edu
3. The CEU is defined by the International Association for Continuing Education and Training (IACET). The definition of the unit and the processes for granting and receiving CEUs is available online on the World Wide Web at http://www.iacet.org
4. A complete description of this program may be found online at the University of Wisconsin World Wide Web site: http://www.engr.wisc.edu/general/depts.html
5. The IEEE World Wide Web site is found at: http://www.ieee.org
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16. The criteria are known as "Criteria 2000" or "EC2000" and are available on the World Wide Web at: http://www.abet.org

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CONTINUOUS MEDIA. See DISTRIBUTED MULTIMEDIA SYSTEMS.

CONTINUOUS PHASE MODULATION. See MINIMUM SHIFT KEYING.

CONTINUOUS PROCESSES. See PAPER INDUSTRY.

CONTINUOUS-TIME CONTROL SYSTEM DESIGN. See CONTROL SYSTEM DESIGN, CONTINUOUS-TIME.

CONTRACTING. See OUTSOURCING.