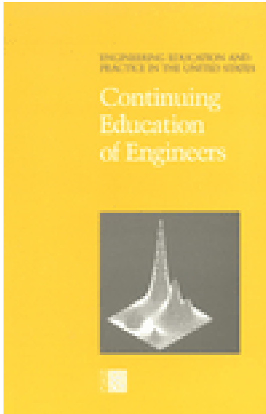

Continuing Education of Engineers

Panel on Continuing Education, Committee on the Education and Utilization of the Engineer, National Research Council

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Continuing Education of Engineers

Engineering Education and Practice in the United States

Panel on Continuing Education
Committee on the Education and Utilization of the Engineer
Commission on Engineering and Technical Systems
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Support for this work has been provided by the National Science Foundation, the Department of the Air Force, the Department of the Army, the Department of Energy, the Department of the Navy, and the National Aeronautics and Space Administration. Additionally, assistance has been provided through grants from the Eastman Kodak Company, Exxon Corporation, the General Electric Company, the IBM Corporation, the Lockheed Corporation, the Monsanto Company, and the Sloan Foundation.

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Preface

This report of the Panel on Continuing Education was prepared as part of the study of engineering education and practice in the United States that was conducted under the guidance of the National Research Council Committee on the Education and Utilization of the Engineer. A summary of the material from this report is included in the report of the committee;* the various topics are addressed in more detail here.

It was a great pleasure to work with the Panel on Continuing Education in the generation of this report and in support of the major study of the Committee on the Education and Utilization of the Engineer. I would like to thank the members of the panel for their help in the preparation of this report which reviews the total spectrum of activities in continuing education and highlights the needs for continuing education in the utilization of engineers in our society. Finally, I want to thank Jerrier Haddad and Jordan Baruch for their valuable and helpful support and guidance in the studies that were undertaken. Also, I particularly want to thank the staff who so diligently supported our activities during the course of this study and the production of the report.

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CHAIRMAN

* *Engineering Education and Practice in the United States: Foundations of Our Techno-Economic Future* (Washington, D.C.: National Academy Press, 1985).

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ENGINEERING EDUCATION AND PRACTICE IN THE UNITED STATES

Continuing Education of Engineers

Executive Summary

The education of engineers in many ways is only beginning when they receive their degrees and go to work. The direction of an engineering career may change from time to time—from design to engineering management, for example—but even if it changes very little, the technology with which it deals is changing continually. Engineers cope with such change and succeed in their careers by means of a continuous learning experience.

Learning throughout an engineer's career involves three general mechanisms: experience on the job; informal learning (reading journals, attending technical meetings, and similar efforts); and formal education and training programs. This report is devoted to the formal education and training programs referred to as continuing education, a relatively small but important part of an engineer's career-long deliberate learning process. Education is defined here as the process of expanding the general knowledge of the engineer through formal classes; training is the process of acquiring the specific skills required for a defined job function. Together the two comprise continuing education, the periodic career-long process that follows an engineer's degree-granting education.

FINDINGS

This report first treats continuing education from the engineer's point of view. It then examines the role of industry, academia, profes sional societies, proprietary schools, and government in continuing education. While our detailed findings and recommendations appear in the body of the report, the major findings are summarized below:

- A meaningful body of knowledge has begun to accumulate regarding continuing education from the perspective of the engineer. However, most of it is derived from studies conducted prior to 1980 with support from the National Science Foundation. Whether these results are applicable to current conditions in engineering cannot be ascertained at present.
- All evidence indicates that most engineers participate in continuing education at some point in their careers and that such participation has been growing.
- Employer tuition support has been the most important source of funds for continuing advanced education among engineers.
- The evidence appears to be too limited to arrive at any conclusions about the impact of continuing education on the individual engineer. Despite the enormous resources allocated to continuing education, relatively little is known about its effects.
- Industrial continuing education programs vary in size, type, and complexity and display no consistent pattern. Each program responds to a company's particular needs. The continuing education programs that seem most successful are those developed with a clear commitment to the companies' objectives.
- Methods of evaluating continuing education programs are not consistent and have not been designed to examine benefits that may accrue to the company sponsoring or supporting the programs. The lack of clear-cut objectives for the programs makes evaluation difficult.
- Continuing education has a low priority in the large majority of universities. Neither the institutions nor their faculties have significant incentives to participate in continuing education programs.
- Professional societies in recent years have sharply expanded their efforts in continuing education, but they could do much more in designing and presenting professional development programs to their members. A major difficulty in doing so is the lack of solid information on members' needs, the extent of current activities, and similar points.

CONCLUSIONS

From its findings, the panel has drawn the following conclusions:

- Engineers can work productively over a longer period if they have access to effective continuing education. Although business cycles can affect the demand for engineering work, engineers should always be considered a national resource. As such, they must be given the opportunity for continuing education regardless of business cycles if they are to remain on the frontiers of their profession. Continuing education is an entity in itself and can no longer be viewed as an "add-on" role of industry or academia.

- Continuing education of engineers is essential to increasing national productivity. Technology is changing and interdisciplinary approaches to engineering are becoming more and more common. Thus, new science and mathematics must be regularly introduced to engineers. In addition, engineers continually need to develop nontechnical skills that are not imparted by their formal training.
- The need for continuing education is recognized by all involved. Engineers are seeking ways to remain professionally current; industry invests large sums in continuing education programs; professional societies have offered programs for their members for many years; and academia is involved (although universities give low priority to continuing education and try to extend traditional course work to industry).
- Although the need for continuing education is well recognized, no clear objectives for such programs or ways of assessing their effectiveness have been established by any of the individuals and organizations involved.

RECOMMENDATION

In addition to the detailed recommendations in the body of this report, the panel has developed from its findings and conclusions the following overriding recommendation:

The National Science Foundation (NSF) or other appropriate organization should undertake a program designed to establish the spectrum of values and objectives of continuing education for individual engineers, industry, and academia and to describe how continuing education could or should operate in the engineering world of tomorrow. Because most universities do not have the resources (and most faculty lack the incentives) to produce quality continuing education programs, the NSF project should examine the impact of industry's assumption of this responsibility.

1

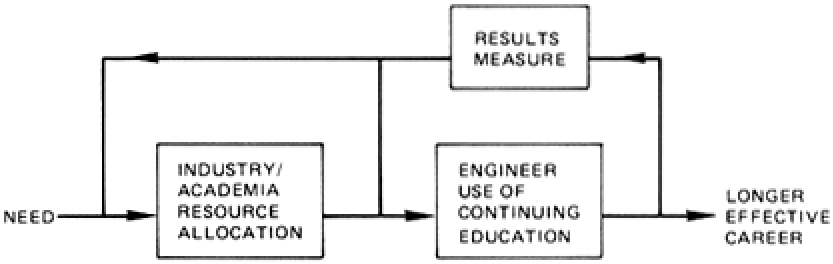
Introduction

When engineers complete their preemployment education and accept employment—whether in industry, academia, or other sectors—their need for education does not end. In many ways it is just beginning. The focus and direction of an engineer's career may change from time to time, and education is needed to prepare for each new direction. Even if the direction of a career changes very little, its focus must shift because the technology is continually changing. The basic function of engineering is to translate science and mathematics into applications; new science and mathematics, then, must be continually introduced to the working engineer. For example, the electronic design engineer who graduated 30 years ago or more may have designed electronic equipment ever since, but the focus of those design efforts has changed from vacuum tubes to transistors to integrated circuits to very large scale integration (VLSI) of circuits. Only through continuing education can competence be maintained throughout such a career.

Continuing education has two major elements: education and training. Education imparts the kinds of information that the engineer integrates into the working knowledge he applies as needed to solve whatever problem is at hand. Training, on the other hand, imparts skills that the engineer needs to perform specific tasks. Learning throughout an engineer's career involves three general mechanisms: experience on the job; professional development (reading journals and attending seminars, technical meetings, and similar events); and formal education and training programs. This report addresses the third of these mechanisms, which accounts for a relatively small but significant part of the engineer's career-long deliberate learning process. Any advanced or degree-granting education that occurs subsequent to employment is considered continuing education in this report.

Traditionally, training has been emphasized by industry, while employee education has had less emphasis by industry as well as universities. However, there are signs that industry is beginning to see the need for more of the education element of continuing education.

Some engineers can maintain their competence without additional structured education and training. But these individuals are a minority. Most engineers need continuing education throughout their careers if they are to remain competitive in the job market. Likewise, companies require competent engineers to remain competitive in their markets. To achieve their goals, both the individual engineer and industry must perceive the usefulness of and the need for continuing education. When that need is adequately perceived and articulated through appropriate needs assessment methodology, the suppliers of continuing education will provide the necessary resources. These suppliers—industry, universities, professional societies, commercial trainers, and government—have a strong vested interest in allocating the required resources to education and training. But too often they are hampered in their efforts because the need for continuing education is not understood, due to insufficient feedback on its results and value. When such feedback is lacking, or is unfavorable, or is not understood by the engineer, participation in continuing education will be minimal. Similarly, when such feedback does not reach the supplier, resources will not be allocated for continuing education. The process is illustrated in the model that appears below. As shown in the model, the need for more education and training that is perceived by the engineer and the sup



plier (e.g., industry, universities, and professional societies) is the driving function; a longer, more effective engineering career is the output. Able, competent engineers produce better work, resulting in more effective industry, government, and private engineering firms.

Thus, national productivity depends in part on such effective engineering careers. The longer an engineer remains competent, the greater the contribution to productivity, particularly if engineering shortages should occur. And, while long and effective careers do not result solely from continuing education, their extent and effectiveness can be substantially increased by it. Hence, continuing education becomes essential to the engineer's performance and in fact is the portion longest in duration of an engineering education.

To be effective, continuing education should be able to respond much faster than academic curricula to changes in the state of the art. While it is risky to predict specific changes, in considering the course of continuing education it is certainly useful to have some idea of the types of careers that engineers will have. Therefore, the panel has assembled a list, which appears below, of developments that are likely to affect the careers of engineers during 1990–2000.

- A multidisciplinary approach to engineering will be required. New technologies will cause a blurring of the boundaries between engineering functions (e.g., design, manufacturing, marketing, management).
- The pervasive growth of management information systems means that there will be fewer middle management positions and engineers will be required to remain longer in technical functions.
- Both industry and government will attempt to control costs by increasing productivity and quality. Therefore, continuing education will be scrutinized more carefully.
- Growth in computer applications and simulations will spur rapid growth in other technologies.
- The impact of artificial intelligence on software will reduce the emphasis on computer programming.
- Applied mathematics will make a resurgence in engineering.
- Computer-integrated manufacturing will be introduced in most areas of industry.
- Bioengineering and genetic engineering will be introduced into areas traditionally associated with more classical approaches.
- Technology and society at large will become more closely integrated.
- Nontechnical skills, such as planning and communications, will play an increasingly important role in engineering work.

In this report, the panel first examines continuing education from the engineer's point of view. It then covers the roles of industry, the universities, professional societies, proprietary organizations, and government in continuing education for engineers. In its examination of continuing education, the panel has reached the conclusion that it is in an inadequate state of affairs. Therefore, some positive recommendations on methods for improving continuing education for engineers are included in each section.

2

Participation in Continuing Education—The Engineer's Perspective

This chapter focuses on the engineer as a user of continuing education and evaluates current information about continuing education participation with respect to the following questions:

1. Why do engineers participate (or not participate) in continuing education?
2. How do the needs and motivation of the engineer vis-à-vis continuing education differ with career stage?
3. To what extent do engineers participate in various types of continuing education?
4. Does participation in continuing education by engineers vary by level of education, career stage, field, size/location of firm, or employer financial support?
5. How does continuing education affect an engineer's career?

The panel addressed these questions by evaluating published research results and analyzing data already collected rather than by conducting new studies. Several difficulties are inherent in this approach.

First, most of the published studies that relate to the engineer and continuing education were done in the late 1970s—some, even earlier. Few, if any, studies have been conducted in the 1980s. The reason for this gap is that support for research on continuing education for engineers came primarily from the National Science Foundation (1977b), which has not funded such research since about 1980. Without more current data, we cannot ascertain whether the results obtained in the late 1970s or earlier are applicable to present conditions in the field of engineering. This caveat should be kept in mind by the reader when reaching conclusions based on the material presented here.

Second, existing survey data present several problems. One is the time lag involved in making surveys available for public use. For example, a major study analyzed here is the Bureau of the Census Survey of Natural and Social Scientists and Engineers (NSSE), a biennial longitudinal survey for 1972–1978. This was the most recent survey for which public-use tapes were available and that included a representative sample of working engineers. Thus, the caveat on conclusions noted for the published studies also applies to the analysis of the NSSE survey. A second problem with the NSSE data is that the scope of the survey was very broad; continuing education was not its focus. The results, therefore, cannot answer many of the panel's questions. (Moreover, many questions cannot be answered directly by the raw data but require major manipulations of variables involving extensive, time-consuming, and often difficult programming.)

Given these limitations, it is clear that significant gaps in our knowledge of the engineer and continuing education will remain after this analysis is completed. One of its aims, therefore, will be the identification of research needs in continuing education for engineers.

The following sections present the panel's evaluation and analysis of the issues raised in the questions listed above.

MOTIVATION FOR PARTICIPATION

Data from several studies can help explain why engineers participate in continuing education. Two nationwide surveys of engineers were conducted by Battelle Memorial Institute in large urban (Levy and Newman, 1979) and small nonurban firms (Welling et al., 1980). These surveys allow comparisons of engineers' objectives in pursuing continuing education and their employers' perceptions of those objectives. Also, since the questionnaires in the two studies were somewhat comparable, the panel compared data on most (but not all) the objectives of engineers pursuing continuing education in large urban and small nonurban firms.

For engineers in large urban firms, the most important reason for participating in continuing education was to prepare for increased responsibility (Table 1). For those in small nonurban establishments, however, the most important aim of continuing education was to perform their present jobs better. This difference may be a result of the greater number of opportunities for increased responsibility in larger organizations. Such a difference is not seen in the two studies between employers, who rate preparation for increased responsibility and attaining better performance in the present job as equally important objectives of continuing education.

TABLE 1 Judged Importance Ratings by Engineers and Their Employers of Employee Objectives for Participation in Continuing Education

Objective	Engineers Urban (N = 100)	Nonurban (N = 100)	Employers Urban (N = 85)	Nonurban (N = 76)
Prepare for increased responsibility	3.9	3.2	4.0	3.9
Perform present job assignment better	3.5	3.8	3.7	3.9
Promote intellectual stimulation	3.7	3.2	3.2	2.9
Prevent obsolescence	—	3.4	—	3.3
Attain increased knowledge	3.3	—	3.7	—
Attain enhanced or authority position in new field	—	3.0	—	3.6
Remedy deficiencies in initial training	3.0	2.6	2.7	3.1
Prepare for new job in same field	2.9	2.7	3.5	2.7
Prepare for new job in new field	2.9	2.0	2.5	2.5
Attain a salary increase	2.8	2.0	2.8	2.9
Fulfill requirements for or promotion	2.6	1.7	3.0	2.8
Maintain present position in company	2.5	2.0	2.6	3.1
Get to know others in field	—	2.6	—	2.5
Prepare for or maintain professional registration	—	1.6	—	2.4
Meet expectations of supervisor	2.1	1.7	2.2	2.4

NOTE: Rating scale ranges from 1 (not at all important) to 5 (of highest importance).
SOURCE: Levy and Newman (1979); Welling et al. (1980).

Preventing obsolescence is rated the second most important objective of continuing education by engineers in small nonurban firms. This supports the results of earlier studies, which found this to be the number one objective (Kaufman, 1974, 1975). The prevention of obsolescence goal was not included in the survey of large urban firms; in those organizations engineers considered intellectual stimulation the second most important objective. However, factor analysis of the data (presented below) shows that engineers who chose intellectual stimulation as an objective tended also to believe that continuing education was important to prevent obsolescence. Regardless of the size of the firm employers tended to perceive intellectual stimulation as a less important objective of continuing education than did their engineers.

These findings are partly supported by the results of a recent survey of Institute of Electrical and Electronics Engineers (IEEE) members

(Adam, 1984), which found that the two most important reasons why they took educational courses were to learn new technology (59.2 percent) and to obtain intellectual stimulation (40.1 percent). In contrast, the two most important employer objectives for continuing education were to prepare engineers for increased responsibility (53.7 percent) and to perform present job assignments more efficiently (46 percent).

The size of the firm may also affect the rewards and the perceptions of rewards for participation in continuing education. Engineers in small nonurban firms, for example, were less likely to participate to attain a salary increase or a promotion than were those in large urban establishments (see Table 1). Furthermore, while small nonurban employers rated the salary and promotion objectives of continuing education as much more important than did their engineers, such differences were not found in large urban companies. It would appear that small non-urban establishments may not be providing (or communicating the existence of) rewards—as well as opportunities for increased responsibility—that could motivate engineers to pursue continuing education.

Among the lowest rated objectives for participation in continuing education was to meet the expectations of the supervisor, a finding that has been corroborated by the IEEE survey (Adam, 1984). Once again, engineers in small nonurban firms provided the lowest ratings. The importance of supervisors in motivating their engineers to participate in continuing education has long been known (Kaufman, 1974, 1975). From the results of the Levy and Newman and the Welling et al. studies, it would appear either that few supervisors expect their engineers to participate in continuing education or that supervisors fail to communicate that expectation when it does exist.

Factor analyses of engineers' objectives in pursuing continuing education identified several broad, relatively independent categories of motivation. Each category includes related objectives that can be summarized as follows (not in order of importance): to maintain and improve job performance; for increased responsibilities, advancement, and rewards; for intellectual stimulation; and to prepare for a new job.

While the studies cited above indicate that differences in work environments apparently do affect engineers' motivation to participate in continuing education, the data are too limited to arrive at any meaningful conclusions.

BARRIERS TO PARTICIPATION

A question related to motivation is why engineers do not pursue continuing education. However, in the two studies discussed above, it was asked only in the survey of small nonurban firms (Welling et al., 1980). The most frequent reason engineers gave for not participating (cited by almost two-thirds of the respondents) was their prohibitive distance from sources of continuing education (Figure 1). The next most important barrier (for almost half) was that needed courses were not offered conveniently (i.e., were not offered at all or were not offered at times when the individual could attend). About one-third did not participate in continuing education because other personal commitments were more important. And approximately one-quarter of the engineers indicated that they did not pursue continuing education for a host of reasons (including no need for it in their present positions, no payoff in terms of organizational rewards, and no encouragement by their immediate supervisor).

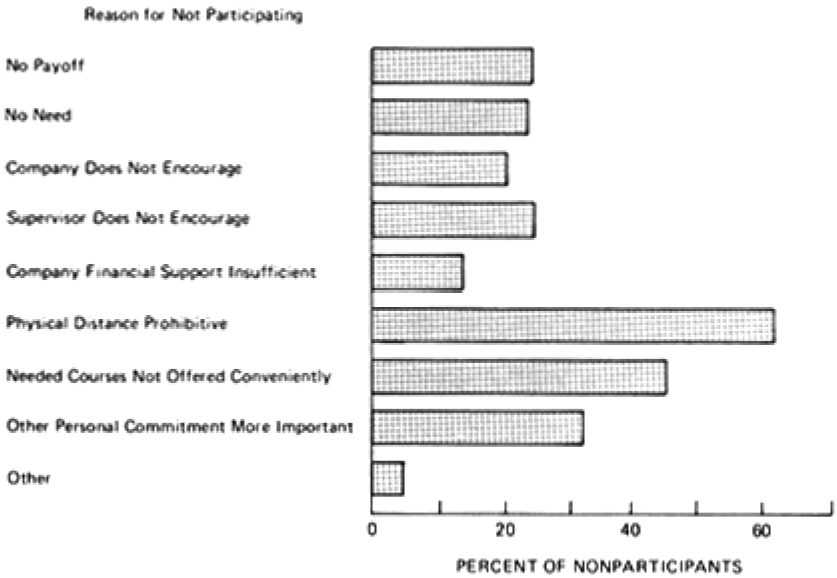


Figure 1
Employee reasons for not participating in continuing education within the last three years. Source: Welling et al. (1980).

From these results it is clear that while organizational barriers and personal commitments deter engineers in small nonurban firms from participating in continuing education, the greatest obstacles are the distance, inconvenience, and unavailability of courses. To determine whether the distance barrier could be overcome, the engineers in the survey were asked how far they were willing to travel for continuing education. They were most willing to travel far to attend workshops, seminars, and conferences that involved at least one overnight stay (Table 2 and Figure 2). For continuing education activities not involving an overnight stay, the acceptable distances were relatively short and diminished rapidly as the number of regular trips increased. It appears that while engineers in small nonurban firms are willing to travel some distance to participate in continuing education, they may still be too far from locations where courses they want are offered. In these situations, alternative instructional media—for example, video—would be one way to overcome the barrier.

For engineers employed in urban areas the obstacles to pursuit of continuing education may not be that different. One study that provided data on this issue was a survey of more than 5,000 engineering society members residing in the Washington, D.C., metropolitan area (Ehrlich, 1980). Ehrlich determined that lack of time was the most important barrier, followed closely by inconvenient location, inconvenient time, and unavailability of courses (Table 3). Physical distance as a barrier was not measured directly in this study; however, the importance of the inconvenient location barrier indicates that physical distance may also be a major deterrent to engineers in urban areas. Lack of time can also be associated with physical distance, but it is probably related more to personal and work commitments. Of additional bear

TABLE 2 One-Way Travel Distances Judged Reasonable for Participation in Continuing Education (by Mode of Educational Delivery)

Mode of Delivery	Mean (miles)	Standard Deviation (miles)	Range (miles)	Median (miles)	Number of Employees
One-day workshop/ seminar/ conference with no overnight stay	93.1	57.5	25–500	97.5	179
Workshop/ seminar/ conference of at least one day with at least one overnight stay	278.8	355.5	25–3,000	198.1	176
Once a week for a quarter/ semester	48.1	32.0	5–250	48.0	169
Twice a week for a quarter/ semester	37.8	26.2	1–250	30.8	167
More than twice a week for a quarter/ semester	26.4	19.0	1–150	24.3	163

SOURCE: Welling et al. (1980).

ing is that 35 percent of the engineers in this study were working as managers and were probably required to devote more time to their jobs than nonsupervisory engineers. In general, it appears that, despite the greater availability and proximity of educational institutions, the most important barriers to continuing education participation for engineers in an urban area are similar to those in nonurban areas. Whether this

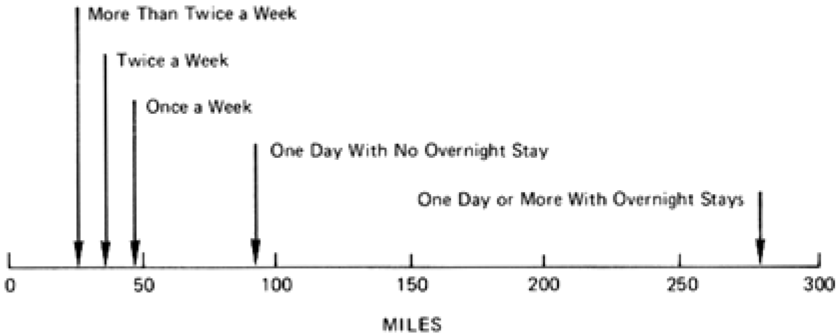


Figure 2
One-way travel distances judged reasonable for continuing education.
Source: Welling et al. (1980).

TABLE 3 Barriers to Continuing Education Participation by Engineers in the Washington, D.C., Metropolitan Area (Percent)[a]

Barrier	Very Significant Barrier	Moderately Significant Barrier	Slightly Significant Barrier	Insignificant Barrier
Lack of time	42.2	28.6	14.8	14.1
Inconvenient location	38.1	26.8	15.7	19.2
Inconvenient time	37.1	26.0	18.2	18.4
Course not available	35.2	18.2	15.2	31.0
Course poorly presented	16.5	21.5	20.7	40.5
Unaware the course was offered	17.2	19.7	22.2	40.5
Lack of incentive	12.4	23.2	25.2	38.8
Insufficient employer financial support	17.4	14.9	16.3	51.0
Educational level too low	10.8	15.1	17.3	56.3
Educational level too high	2.9	7.9	13.2	75.5

[a] Percentages are based on 4,447 respondents.
SOURCE: Ehrlich (1980).

conclusion applies to all urban areas—including those with a high density of private, high-technology firms—remains to be demonstrated.

MOTIVATION AND BARRIERS AMONG OLDER ENGINEERS

Studies of older engineers produced somewhat different results in terms of motivation and barriers to continuing education. Kaufman (1982a) examined the major goals of participation in specific continuing education courses of older engineers (with a mean age of 50) in six large technology-based organizations. Almost half of the sample had participated in formal courses during the previous three years. The results revealed that by far the most important goal of these engineers was better performance in their present jobs (Table 4). In fact, more than three out of five engineers took courses with this goal in mind. The study also showed that more than one-fifth of the engineers enrolled in courses for the intellectual stimulation they provided; somewhat fewer participated to prepare for increased responsibility.

In the Battelle studies (Levy and Newman, 1979; Welling et al., 1980) these goals were also important—but not as important as they were to the older engineers. The lower mean age—the mid-30s—of the engineers in the Battelle studies probably accounts for this difference. Not one of the older engineers gave a salary increase or promotion as his goal in pursuing continuing education. And it is very likely that the older engineers had only limited opportunities for advancement, in which case continuing education would not have helped. Among older engi

TABLE 4 Major Goals of Older Engineers in Six Organizations Who Participated in Continuing Education[a]

Goal	Percentage
Perform the present job assignment better	61.1
Promote intellectual stimulation	22.7
Prepare for increased responsibility	19.2
Meet the expectations of the supervisor	8.3
Prepare for a new job in the current field	7.3
Enhance one's position in the field	7.3
Remedy deficiencies in initial training	3.6
Prepare for a new job in other fields	3.6
Fulfill requirements for promotion	0.0
Obtain a salary increase	0.0

[a] N = 81.
SOURCE: Adapted from Kaufman (1982).

neers, therefore, continuing education appears to be focused primarily on job-related needs.

Kaufman also asked older engineers why they did not participate in continuing education. Clearly, the most important reason they cited was that too much time would be taken from family or personal life (Table 5); more than half of the engineers rated this reason as moderately or extremely important. Another obstacle the engineers cited, which may have been related to the personal life response, was the travel time required (this was an important barrier to about one out of four respondents). Almost as many were affected by the offering of courses during work hours; their job requirements obviously did not allow them to take time off, and they were apparently unwilling to devote their personal time to continuing education. For about one respondent out of five, continuing education was not required for the job. Relatively unimportant factors in not taking courses were prerequisites, financial support, and competition from recent graduates.

Continuing education participants and nonparticipants generally did not differ significantly in their ratings of barriers—with one exception. Engineers who had taken no courses in the previous three years were much more likely than course participants to have jobs that did not require them to do so. Thus, an engineer's job appears to be an important determinant of participation in formal continuing education courses.

In general, barriers to continuing education participation tended to be less prevalent among these older engineers than among engineers in

TABLE 5 Reasons Given by Older Engineers for Not Participating in Courses[a]

Reason	Percent Rating Reason as Moderately / Extremely Important	Mean Rating
Too much time taken from family/personal life	52.1	3.4
Too much travel required	23.1	3.1
Courses offered during working hours	21.4	2.1
Job does not require more education	17.5	2.8
Not having adequate prerequisites	6.2	1.7
Financial burden too great	7.8	1.4
Possible competition from recent graduates	1.4	1.4

[a] N = 147.
SOURCE: Kaufman (1982a).

other studies. This may very well be an artifact of the commitment to and resources provided for continuing education by the older engineers' employers. An indication of the accuracy of this possibility is the lack of financial obstacles to course participation among these engineers in contrast to those in other studies.

One final interesting point is that there is some evidence indicating that the motivation to learn may decline among older engineers (Dubin et al., 1973; Kaufman, 1974, 1975). But there is also very little research on why such a decline should occur. Understanding how the needs and motivation of engineers to participate in continuing education change with career stage is a major gap in our knowledge of lifelong engineering learning.

FACTORS THAT DETERMINE PARTICIPATION

As mentioned earlier, it is difficult to obtain accurate recent data on the degree of participation of engineers in continuing education. In the mid-1960s LeBold et al. (1966) conducted a national sample of more than 4,000 engineers. That study, one of the most comprehensive to date, revealed that 73 percent of the engineers surveyed felt that in their fields formal instruction in modern developments in technology was necessary to keep up to date; a total of 77 percent agreed that short courses (as opposed to advanced degree work) would be sufficient for such updating. Despite this seeming consensus on the value of short courses, however, only 54 percent of the engineers reported ever receiving noncredit education or training.

The situation may have improved by the early 1970s. By then an estimated 68 percent of the nation's engineers who provided information on continuing education to the National Science Foundation (1975a) reported having received some type of nondegree training. However, only 34 percent reported participating in employer-sponsored in-house courses and 24 percent pursued correspondence or extension courses. Other types of education reported by engineers included formal, postapprenticeship, on-the-job training (24 percent); courses at adult education centers (18 percent); and military training applicable to civilian occupations (17 percent). Thus, although about two-thirds of engineers by the early 1970s reported having received some type of continuing education, much of it may have come earlier in their careers.

The following sections discuss various factors that may affect an engineer's participation in continuing education.

Educational Level

Some evidence indicates that participation in continuing education is related to the engineer's educational background and field. According to National Science Foundation (NSF) data (1975a), the percentage of engineers who had participated in any kind of program declined dramatically with increasing education (Table 6). Almost 9 out of 10 engineers without a college education had received some type of training program, compared to only half of the Ph.Ds. Indeed, continuing education may well be a path to becoming an engineer for those with limited educational background, although the pattern of training may differ depending on its extent. The NSF data showed that for those with no college education, extension or correspondence courses were predominant with well over half of such engineers enrolled in training programs of this type. For engineers with an associate's degree or some college education, employer-sponsored courses were most popular (more than two-fifths having enrolled); in addition, more than one-third of these engineers enrolled in extension or correspondence courses.

Engineers with bachelor's and master's degrees also favored employer-sponsored courses, but only about one out of three had actually participated in such training. And relatively few Ph.D. engineers had pursued any specific kind of continuing education. (As an explanation of this phenomenon it might be argued that Ph.D.s would be expected to continue to learn on their own, especially through their research. Another possibility may be that Ph.D.s are actually attending professional society courses, which were not included in the survey.)

TABLE 6 Percentage of Engineers Who Had Received Training During Their Career (by Educational Attainment in 1972)

All Engineers	Total	No College	1–3 Years College	Associate of Arts and Science	B.S.	Master's	Ph.D.
Any training	67.9	86.3	79.3	72.3	68.1	66.4	50.1
On the job	24.3	23.4	27.0	23.6	25.3	22.3	11.7
Employer courses	34.1	32.2	40.5	42.6	35.2	32.2	13.8
Extension/ correspondence courses	23.9	54.8	34.1	35.1	22.9	23.7	15.1

NOTE: Data are based on a weighted population of engineers, excluding nonrespondents.
SOURCE: National Science Foundation (1975a).

With the exception of Ph.D.s, formal, on-the-job training was received by about one out of four engineers, regardless of their education.

Engineering Field

NSF data showed that participation in training varied widely with the engineer's field (Table 7). Training was most prevalent among industrial, aeronautical, electrical, and mining/petroleum engineers and least prevalent in chemical, agricultural, metallurgical/ materials, and civil engineering. The prevalence of specific kinds of training tended to follow somewhat similar patterns. Participation in employer-sponsored courses, for example, was greatest among industrial, mining/petroleum, aeronautical, and electrical engineers. On-the-job training, however, was more likely to be received by mining/petroleum, nuclear, and industrial engineers.

According to the NSF data, training tended to be prevalent in certain engineering fields regardless of educational level (Table 8). Aeronautical engineers, for example, had very high participation rates at all educational levels but the doctoral. Industrial and mining/petroleum engineers had high participation rates at all educational levels with the exception of those with only one to three years of college. Low participation rates tended to occur at almost all educational levels among

TABLE 7 Percentage of Engineers Who Had Received Training During Their Career (by Field in 1972)

Engineering Field	Any Training	On the Job	Employer Courses	Extension/ Correspondence Courses
All fields	67.9	24.3	34.1	23.9
Aeronautical	73.7	23.2	40.8	23.9
Agricultural	58.5	25.5	33.1	22.2
Chemical	57.7	21.0	25.9	17.5
Civil/environmental	60.4	22.3	21.2	24.4
Electrical/electronics	72.1	24.9	39.3	25.3
Industrial	74.1	31.4	46.2	24.0
Mechanical	65.8	20.9	32.2	22.6
Metallurgical/ materials	58.4	20.1	23.3	18.9
Mining/petroleum	71.6	32.8	43.6	20.8
Nuclear	64.6	31.9	32.5	19.3
Other	70.9	27.4	37.3	24.6

NOTE: Data are based on a weighted population of engineers, excluding nonrespondents.
SOURCE: National Science Foundation (1975a).

TABLE 8 Percentage of Engineers Who Had Received Training During Their Career (by Field and Educational Attainment in 1972)

Engineering Field	Total	No College	1–3 Years College	4 + Years College	Associate of Arts and Science	B.S.	Master's	Ph.D.
All engineers	67.9	86.3	79.3	76.1	72.3	68.1	66.4	50.1
Aeronautical	73.7	—	86.4	85.5	79.5	75.5	70.4	49.7
Agricultural	58.5	—	—	—	—	61.0	59.9	—
Chemical	57.7	—	50.0	65.0	—	59.6	63.2	37.9
Civil/environmental	60.4	—	77.7	66.8	73.9	58.3	64.2	48.1
Electrical/electronics	72.1	—	78.9	80.9	64.7	73.6	66.8	58.6
Industrial	74.1	—	76.5	84.4	83.5	73.2	73.8	59.4
Mechanical	65.8	90.1	77.0	83.4	74.0	65.6	63.4	35.9
Metallurgical/materials	58.4	—	58.3	58.0	—	60.4	56.6	55.6
Mining/petroleum	71.6	—	51.0	81.0	—	71.8	70.8	60.8
Nuclear	64.6	—	—	—	—	65.1	75.3	42.4
Other	70.9	73.8	88.7	74.0	79.7	70.4	63.7	54.6

NOTE: Data are based on a weighted population of engineers, excluding nonrespondents.
SOURCE: National Science Foundation (1975a).

chemical and metallurgical/ materials engineers. A notable exception to these trends was electrical engineers, who had relatively lower participation rates at the associate's and master's degree levels, despite a high overall rate.

Trends in Annual Participation Rates

How recently an engineer has participated in continuing education could serve as a good indicator of involvement in updating activities. Based on indicators such as participation rates involvement in continuing education has been increasing. In a study from the mid-1960s, for example, only 27 percent of the nation's engineers had taken short courses or extension courses in engineering or science during the previous year, and 12 percent had completed technical graduate courses (LeBold et al., 1966).

There are indications that participation in continuing education increased during the 1970s. For example, the annual participation rate among engineers in training activities hovered around 46 to 47 percent between 1972 to 1975, but then began to rise, topping 52 percent by 1977 (Table 9). This trend was also evident for on-the-job training, which increased from a 21 percent rate in 1972 to more than 26 percent in 1977. And participation increased among employer-sponsored in-house courses, which went from an annual participation rate of less than 21 percent in 1972 to almost 24 percent in 1977. (The increase in training participation beginning in 1976 was probably associated with a postrecessionary period. Engineers were in demand and new engineers were in short supply owing to the low college enrollments in engineering caused by the recession of 1970–1971, which involved mass terminations of engineers (Kaufman, 1979b, 1982b).)

Preliminary survey data collected by NSF in 1982 reveal that the annual continuing education participation rate continued to increase,

TABLE 9 Annual Training Participation Rates of Engineers During 1972–1977

Type of Training	1972	1973	1974	1975	1976	1977
Any training	46.9	46.8	45.9	46.8	49.9	52.2
On the job	21.0	21.1	20.6	21.0	25.5	26.2
Employer courses	20.7	22.2	22.1	21.5	22.7	23.7
Extension/correspondence courses	5.2	5.2	4.4	4.5	5.1	5.1

NOTE: Data are based on a weighted population of engineers, excluding nonrespondents.
SOURCES: National Science Foundation (NSF) (1975b) and unpublished NSF data.

reaching 61 percent by 1981 among the engineers that responded. (This rise is all the more significant because on-the-job training was excluded from the survey.) The major increase was in employer-sponsored "in-house" courses in which 37 percent had enrolled, up 13 percent since 1977. Significant participation was evident also in courses offered at professional meetings (20 percent) and by commercial training organizations (19 percent), categories that were excluded in previous NSF surveys. About 20 percent earned continuing education credit units.

The general trend of participation in training that was found for the engineer's career as a whole (i.e., declining with increasing education) also applies to the annual participation rate (Table 10). During 1972 and 1973 more than half of those engineers with an associate's degree received some type of training compared to only about one-third of those with doctorates. Such trends were maintained for specific kinds of continuing education including formal on-the-job training and employer-sponsored courses.

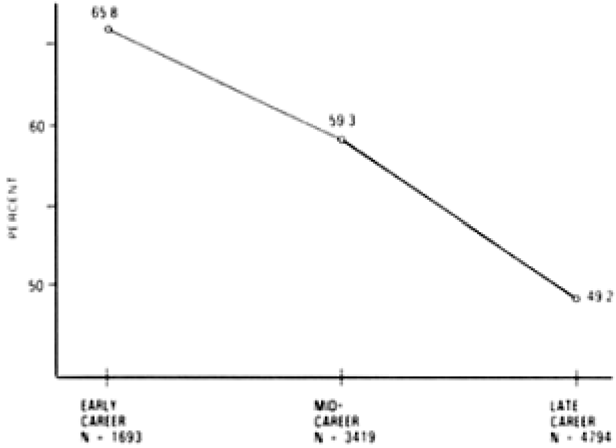
Career Stages

The rate at which engineers participate in continuing education clearly tends to decline with age or career stage. For example, preliminary analyses of the Bureau of the Census data show that almost two out of three engineers in the early stage of their careers participated in employer-sponsored in-house courses during 1972–1977 (Figure 3). But the rate declined to less than three-fifths for midcareer engineers, and to less than half for older engineers. Over the six-year period the older engineers maintained a relatively low and fairly constant participation rate, but the young and midcareer engineers tended to increase their rates (Figure 4). Some of these trends are reflected in preliminary analy

TABLE 10 Annual Training Participation Rates of Engineers During 1972 and 1973 (by Educational Attainment)

	Any Training		On the Job		Employer Courses		Extension Correspondence Course	
Education Level	1972	1973	1972	1973	1972	1973	1972	1973
Doctorate	33.7	35.5	13.8	13.7	13.4	14.8	4.0	4.7
Master's	48.1	47.8	18.6	19.0	21.7	22.4	5.8	5.5
Bachelor's	47.1	46.8	21.9	21.9	20.7	22.5	5.0	5.0
Associate	55.7	57.6	28.5	31.8	29.8	30.2	5.9	6.8
No degree	48.3	50.0	22.6	22.4	20.5	20.9	5.6	7.3

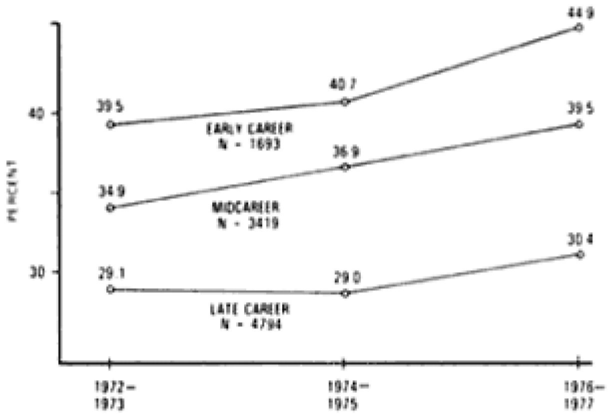
NOTE: Data are based on a weighted population of engineers, excluding nonrespondents.
SOURCES: National Science Foundation (NSF) (1975b) and unpublished NSF data.



Note:
Career stage was based on age in 1972, with those in "early career being under 30 years old midcareer, between 30 and 39 years; and late career, 40 years and over.

Figure 3
Percentage of participation in company-sponsored in-house courses among engineers at three different career stages (1972–1977).

Source:
Preliminary analysis of the Bureau of the Census Survey of Natural and Social Scientists and Engineers, 1972–1978.



Note:
See Figure 3 for career stage definition.

Figure 4
Percentage of participation in company-sponsored in-house courses among engineers at three different career stages during two-year periods over six years.

Source:
Preliminary analysis of the Bureau of the Census Survey of Natural and Social Scientists and Engineers, 1972–1978.

ses of data on engineers who completed master's degrees. Of younger working engineers, for example, 12.5 percent completed a master's degree during 1972–1977 (Table 11); during the same period, only 4.9 percent of midcareer and 0.9 percent of older engineers completed a degree. (These data should be interpreted in light of the fact that engineers already possessing master's degrees were included in this preliminary analysis. If they were excluded, the rates would be higher.) It is interesting to note that beginning with the midcareer group master's degrees in business administration or management become at least as popular as the engineering degrees. In part this reflects the fact that many engineers have management responsibilities by midcareer and need to fill relevant gaps in their knowledge and skills.

Some of these results are reinforced by a study of older engineers conducted by Kaufman during the late 1970s (1982a). Almost half of these engineers participated in some type of formal course during the three years prior to the survey (Table 12). Most popular were the technical courses, followed closely by computer and then management types of courses (which consumed considerably less time than the first two).

The popularity of technical courses even among older engineers is corroborated by the recent survey of IEEE members (Adam, 1984). The nature of these courses varied widely (Table 13). As might be expected, most of the formal continuing education comprised noncredit in-house courses, although accredited courses offered primarily by universities attracted some participation. In their choice of courses most engineers emphasized those providing specific skills rather than general knowl

TABLE 11 Percentage of Employed Engineers at Different Career Stages Who Completed Master's Degrees During 1972–1977

Field in Which Master's Degree Was Completed	Early Career[a] (N = 3,042)		Midcareer[a] (N = 6,578)		Late Career[a] (N = 10,636)	
N	%	N	%	N	%	
None	2,663	87.5	6,256	95.1	10,537	99.1
Engineering	144	4.7	116	1.8	35	0.3
Business/management	129	4.2	120	1.8	36	0.3
Physical/mathematical sciences	16	0.5	11	0.2	3	0.0
Other	90	3.0	75	1.1	25	0.2

NOTE: This analysis will also be carried out for engineers who possessed only a bachelor's degree.

[a] See Figure 3 for career-stage definition.

SOURCE: Analysis of data from the Bureau of the Census of Natural and Social Scientists and Engineers, 1972–1978.

TABLE 12 Participation in Formal Courses in the Past 3 Years by Midcareer Engineers[a]

Type of Course	Percent Participating	Mean Number of Courses	Mean Class Hours	Mean Participation Hours	Total Hours
Technical/math	27.4	.51	16.1	14.9	11.0
Computer	25.0	.40	14.0	12.8	26.8
Management/ communications	22.0	.35	11.7	6.9	18.6
Total	49.4	1.26	41.8	34.6	76.4

[a] N = 164.
SOURCE: Kaufman (1982a).

TABLE 13 Characteristics of Courses in Which Midcareer Engineers Participated in the Past 3 Years[a]

Characteristic	Percentage of Participating Engineers
Type of courses	
Accredited	14.4
Noncredit	40.2
Source sponsor	
University	13.4
In-house	37.8
Other	9.2
Course emphasis	
Specific skills	15.4
General knowledge	27.4
Relationship to job	
For current job	17.0
For future job	17.1
Not job related	7.9
Level of course	
Introductory	20.1
Intermediate	33.7
State of the art	13.6

[a] N = 164.
SOURCE: Kaufman (1982a).

edge. Even clearer was the greater concentration on studies related to their current job rather than to a future job—relatively few took courses that were not at all job related. Also, participation was greater in intermediate-level courses requiring introductory or basic knowledge or skills than in either introductory or state-of-the-art courses.

Size and Location of Employers

Recent studies indicate that participation in continuing education varies substantially with the size and location of the employer. According to the data in the Battelle studies, 64 percent of the engineers in large urban firms had participated in continuing education during the previous year (Levy and Newman, 1979) as opposed to only 35 percent of those in small nonurban establishments (Welling et al., 1980). The biggest data discrepancies between the two types of firms occurred for courses taken for credit; large urban firms showed substantially higher percentages of participation. Noncredit courses and other educational activities conducted at the firm were also more prevalent in the large urban establishments (Table 14). The only types of continuing education for which participation rates were fairly similar between the two firms were other educational activities conducted away from the firm or organized self-study. It is clear from these data that participation in continuing education by engineers who work in geographically iso

TABLE 14 Percentage of Engineers Who Participated in Continuing Education Over One Year

Type of Continuing Education	Large Urban Firms (N = 144)	Small Nonurban Firms (N = 177)
Advanced degree-related courses	29.9	—
Other degree credit courses	13.9	4.5
Noncredit courses		
Conducted at firm	7.6	1.1
Conducted away from firm	18.8	6.8
Other educational activities		
Conducted at firm	13.9	7.9
Conducted away from firm	25.7	29.4
Leaves with pay	2.0	—
Organized self-study	7.6	7.3
Other	2.8	—
All types combined	63.9	35.0

SOURCES: Levy and Newman (1979); Welling et al. (1980).

lated areas is limited and primarily involves activities offered away from their firms.

Employer Support

All available evidence indicates that employer support for engineering employees enrolled in university courses has long been widespread. In a survey in the mid-1960s, 77 percent of the engineers surveyed reported that their employers provided partial or full reimbursement for part-time university courses; 25 percent also received release time during the day. And 9 percent were able to enroll in graduate degree credit courses on their employers' premises (LeBold et al., 1966).

It is clear that such employer support for university courses has contributed greatly to the education of engineers. By the early 1970s, 41 percent of the engineers pursuing graduate education had received financial support from their employers. In terms of the sources of these funds, only savings and earnings were more prevalent than employer support (Table 15). Of those who received employer support, 40 percent depended entirely on such funds to pursue graduate education, and an additional 46 percent had only one other source (generally their savings or earnings). Indeed, the employer was the single most important source of funds for the graduate education of engineers, with savings and/or earnings next in importance.

By the late 1970s, employer support for advanced and continuing education of engineers had become quite prevalent, but it varied with

TABLE 15 Sources of Funds for Financing Graduate Education of Engineers

	Source Used (N = 4,805)		Single Most Important Source (N = 3,787)	
Source of Funds	N	%	N	%
Employer	1,968	41.0	1,177	31.1
Savings or earnings	2,402	50.0	966	25.5
Research or teaching assistantship	922	19.2	455	12.0
Veteran's benefits	804	16.7	391	10.3
Fellowship	857	17.8	338	8.9
Aid from family	853	17.8	269	7.1
Loans	253	5.3	41	1.1
Other	391	8.1	150	4.0

SOURCE: Preliminary analysis of the Bureau of Census Survey of Natural and Social Scientists and Engineers (1972).

the size of the firm. In one survey, 83.2 percent of 3.34 large urban establishments provided such support, as compared to 45.8 percent of 236 small nonurban firms, with the difference being highly significant (Welling et al., 1980). Related research revealed that 61.3 percent of the engineers in the small nonurban firms whose employers did not provide support for advanced and continuing education had not participated in courses during the previous three years; in firms that did not provide support, only 37.1 percent of the engineers had not participated (Welling et al., 1980). Lack of employer support, therefore, appears to play a significant role in discouraging participation in courses, especially in small nonurban firms where travel time is also a major barrier.

Other research indicates that more than 9 out of 10 engineers working in high-technology firms are reimbursed for tuition, but most of this support is available to engineers early in their careers (Thompson and Drake, 1983). This may partly explain the very low rate of participation in advanced education among midcareer and older engineers.

OUTCOMES OF CONTINUING EDUCATION

Despite industry's enormous investment in continuing education, few studies have addressed the impact of continuing education on the individual engineer. Other than a state-of-the-art review of the research literature in 1977 (Kaufman, 1978a), no comprehensive attempt has been made to assess the outcomes of continuing education for engineers. This brief review is an initial attempt to begin updating that earlier work.

Effectiveness Ratings of Courses

One approach to assessing the outcomes of courses is to obtain global user ratings of their effectiveness. While this method does not provide information on specific outcomes, it does give a gross indication of the utility of different kinds of continuing education for engineers.

In judging the degree of success of continuing education in meeting their objectives, participants who worked in large urban firms rated every kind of continuing education between successful and very successful (Levy and Newman, 1979). Effectiveness ratings by engineers from small nonurban establishments were more variable (Welling et al., 1980). Participants gave the highest ratings to noncredit and other educational activities (e.g., workshops, seminars, conferences) that were conducted away from the firm (Figure 5). Educational presentations at technical society meetings received the lowest ratings. The most disagreement among participants (as indicated by a high standard deviation) occurred for degree-related courses. Comparison of the effectiveness ratings of participants with those of their employers reveals interesting trends. Brief educational activities conducted away from the establishment were rated highly by both participants and employers. Participants rated activities conducted at the establishment as less effective than did their employers. On the other hand, noncredit courses conducted away from the establishment, degree-related credit courses, and organized self-study were all rated more highly by participants than by their employers. Engineers and their employers, therefore, tend to disagree somewhat over what kind of continuing education is the most effective.

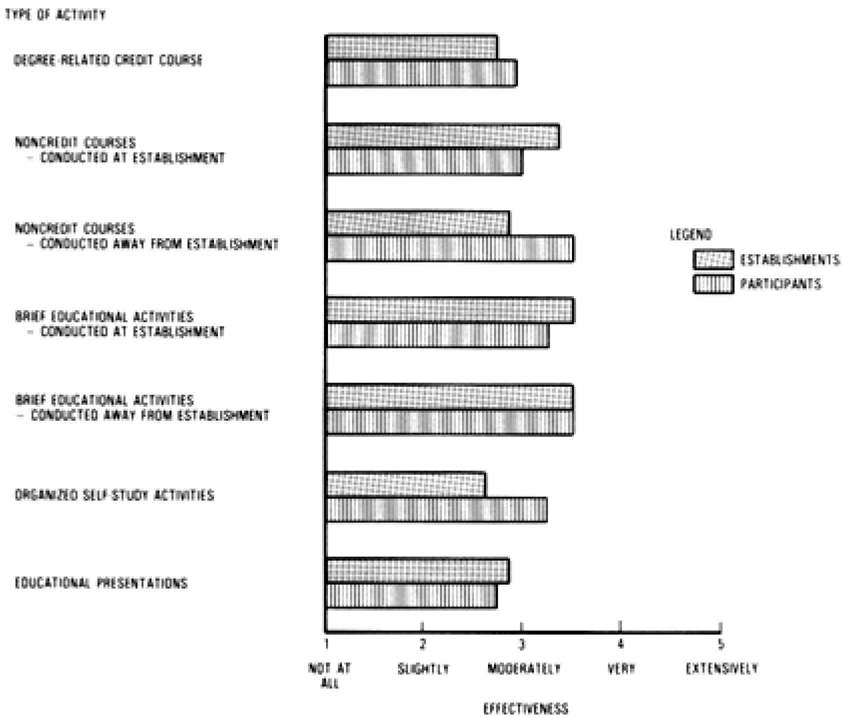


Figure 5
Comparison of the judged effectiveness of continuing technical education as perceived by small nonurban establishments and participants.
Source:
Welling et al. (1980).

A study of engineering society members in the Washington, D.C., area produced somewhat different results (Ehrlich, 1980). College-credit courses for a graduate degree clearly received the highest ratings (Table 16). Other types of continuing education were rated lower, but

TABLE 16 Effectiveness Ratings of Continuing Education by Engineers in the Washington, D.C., Metropolitan Area (Percent)[a]

Type of Continuing Education	Very Effective	Moderately Effective	Slightly Effective	Ineffective	No Experience on Which to Judge
College credit courses applied toward a graduate science or engineering degree	20.8	16.7	7.0	4.4	51.1
	(42.5)[b]	(34.2)	(14.3)	(9.0)	—
Employer-sponsored short courses and workshops (S&E)	19.1	31.7	14.4	4.4	30.3
	(27.0)	(45.4)	(20.7)	(6.3)	—
Professional society short courses	12.3	22.0	10.4	2.9	52.4
	(25.8)	(46.2)	(21.8)	(6.1)	—
College credit S&E courses not being applied toward a graduate degree	11.1	17.7	8.0	3.3	59.8
	(27.6)	(44.0)	(19.9)	(8.2)	—
Short courses sponsored by another agency	9.1	12.7	6.4	2.2	69.5
	(29.8)	(41.6)	(21.0)	(7.2)	—
College S&E noncredit courses	11.0	21.0	10.4	3.3	54.2
	(24.0)	(45.9)	(22.7)	(7.2)	—

[a] Percentages based on 3,938 respondents.
[b] The numbers in parentheses total 100 percent when "no experience" is excluded.
SOURCE: Ehrlich (1980).

all were at about the same level. Among courses provided by universities, those offered at local campuses and at places of employment were rated the highest, and televised or videotape programs provided by universities at the place of employment were rated the lowest (Table 17). For noncredit continuing education, short courses were rated the most effective; live video courses without "talk-back" capability were rated the least effective (Table 18). Compared to the latter, live video with "talk-back" was judged considerably more effective. It appears, then, that the interactive capability provided by "talk-back" is critical in making this mode of instruction effective. Tutored video instruction (TVI) is a technique that has successfully combined live interaction (and its feedback capability) with the flexibility of video (Baldwin and Down, 1981; Gibbons et al., 1977). While the traditional face-to-face courses may be rated as more effective than televised or videotaped programs, the latter, if used in an interactive mode, could be as effective. Other techniques are continually being introduced so that a choice of a delivery system can be made based on course objective, content, and audience.

Job Performance

Few studies have attempted to evaluate the effects of continuing education on the job performance of engineers. A major problem is the difficulty of measuring performance. One approach has been to use managerial performance ratings or rankings. In a study by Kaufman (1978a), there was a positive relationship between the number of graduate courses completed and subsequent job performance. But this was true only for engineers working in research and development (R&D) and not for those in organizations doing more applied work in development or manufacturing. Thus, the work environment has an important impact on continuing education outcomes as well as on participation (Kaufman, 1982a). Also, data across organizations on employer-sponsored in-house training showed consistently that the poorest performers tended subsequently to enroll in the greatest number of in-house courses. However, participation in such courses did not lead to improved performance. One study indicates that in-house courses may have differential effects (Kopelman, 1977). Over a four-year period, performance decreased among R&D professionals who completed in-house courses that were longer than 20 hours; those taking shorter courses improved their performance. It has been suggested that this difference may be more a reflection of the objectives of the participants than of the effectiveness of the courses themselves. Those taking

TABLE 17 Effectiveness Ratings of University Accredited Continuing Education by Engineers in the Washington, D.C., Metropolitan Area (Percent)[a,b]

Type of Continuing education	Very Effective	Moderately Effective	Slightly Effective	Ineffective	No Experience on which to Judge
Programs provided by local colleges and universities	18.2	21.6	6.0	2.1	52.0
	(37.9)	(45.0)	(12.5)	(4.4)	—
Live programs provided by universities at the place of employment	7.6	13.6	4.6	1.9	72.2
	(27.3)	(48.9)	(16.5)	(6.8)	—
Programs provided by out-of-state universities on an extension campus	5.0	9.0	4.1	2.0	79.8
	(24.8)	(44.6)	(20.3)	(9.9)	—
Televised or videotape programs provided by universities at the place of employment	1.6	4.3	4.9	3.8	85.4
	(11.0)	(29.5)	(33.6)	(26.0)	—

NOTE: Responses in the table are in answer to the following question: Considering only continuing education provided by colleges and universities for credit, how would you rate the effectiveness of the following continuing education programs?

[a] Percentages based on 4,477 respondents.

[b] The numbers in parentheses total 100 percent when "no experience" is excluded.

SOURCE: Ehrlich (1980).

TABLE 18 Effectiveness Ratings of Noncredit Continuing Education by Engineers in the Washington, D.C., Metropolitan Area (Percent)[a,b]

Type of Continuing Education	Very Effective	Moderately Effective	Slightly Effective	Ineffective	No Experience on which to Judge
Short courses	24.5	37.8	10.9	1.8	24.9
	(32.6)	(50.3)	(14.5)	(2.4)	—
Seminars and symposia	21.9	37.8	17.6	2.8	19.9
	(27.3)	(47.2)	(22.0)	(3.5)	—
Live video with "talk back"	3.5	8.3	5.6	3.6	79.0
	(16.7)	(39.5)	(26.7)	(17.1)	—
Self-study courses	7.6	25.6	19.5	6.4	40.8
	(12.8)	(43.2)	(33.0)	(10.8)	—
Computer-based instruction	2.5	8.5	8.4	4.4	76.2
	(10.5)	(35.7)	(35.3)	(18.5)	—
Videotape instruction	2.9	12.0	14.5	7.9	62.7
	(7.8)	(32.2)	(38.9)	(21.1)	—
Live video without "talk back"	0.6	5.7	8.9	7.3	77.5
	(2.7)	(25.3)	(39.6)	(32.4)	—

[a] Percentages based on 4,742 respondents.
[b] The numbers in parentheses total 100 percent when "no experience" is excluded.
SOURCE: Ehrlich (1980).

longer courses may have done so to remedy deficiencies in their knowledge and skills, whereas those taking shorter courses may have wished to acquire specific skills that could be readily applied to the performance of their jobs.

Salary

In evaluating the effects of continuing education, salary has been treated as a substitute for or equivalent of performance (Morris, 1978a), but this equating of salary with performance has been questioned (Kopelman, 1979). The results of the study showed that course participation was positively related to salary, although these results have been criticized on several methodological grounds (Kaufman, 1980; Kopelman, 1979), bringing into question the validity of the study's conclusions. Other research has failed to find a positive relationship between participation in continuing education and changes in salary (Kaufman, 1982a).

Obsolescence

The degree to which continuing education for engineers can reduce the obsolescence of technical knowledge and skills has yet to be demonstrated conclusively. Kaufman (1974) defined obsolescence as the degree to which professionals lack up-to-date knowledge or the skills necessary to maintain performance in their work. This definition was adopted by the National Science Foundation (1977a). However, relating continuing education to obsolescence is difficult because of the problems in measuring obsolescence. Some studies have used knowledge checklists (Perucci and Rothman, 1969) or tests of knowledge (Mali, 1969), and such indicators have been found to be related to advanced education. Another method of measuring obsolescence is by means of a self-assessment approach (Kaufman, 1978b). The number of technical courses completed in a three-year period by older engineers was found to be related to lower obsolescence as measured by a self-assessment instrument (Kaufman, 1982a). Indeed, technical courses apparently reduced obsolescence more than either reading or attending professional meetings and seminars.

Innovation

One outcome of continuing education that has barely been touched upon by researchers is innovation, which may be considered the oppo site of obsolescence. Again, the problem in part is measurement. In perhaps the only study linking innovation and continuing education, Ransom (1983) found evidence that those who spent more time in professional development activities maintained significantly higher levels of innovation, based on expert judgments.

Job/Career Changes

The impact of continuing education on job or career changes has rarely been evaluated. One issue of interest is the retraining or reeducation of the midcareer engineer. The introduction and diffusion of major changes in technology often lead to a surplus of experienced midcareer engineers whose knowledge and skills have become obsolescent (Kaufman, 1974, 1975; Schillinger et al., 1980). It would appear that two complementary problems resulting from these changes could be largely ameliorated with a single solution—namely, reducing the shortages of personnel skilled in applying the new technologies by reeducating the surplus midcareer engineers through formal continuing education programs.

Indeed, a federal evaluation has reached the same conclusion: since employer-sponsored continuing education "can provide a rapid and focused means for relieving spot personnel shortages in specific subfields and for improving productivity by renewing the skills of mid-career scientists and engineers in industry, it could provide a relatively cost effective means for the Federal Government to intervene in the science and engineering market when clear national needs require such intervention" (National Science Foundation and Department of Education, 1980, pp. 43–44). However, shortly after the publication of this report, federal support for research and development in the continuing education of engineers, which had been funded through NSF's Directorate for Science Education, ceased completely.

The limited research available on the reeducation of midcareer engineers has focused on government programs for the unemployed (Kaufman, 1982b; Pascal, 1975). Related research has demonstrated that training and educational activities after job loss are associated with significant career change, but a cause-and-effect relationship has not been proven (Kaufman, 1979b). For employed midcareer engineers, academic, industrial, and governmental reeducation activities remain essentially undocumented; research on employer-sponsored midcareer reeducation per se has been reported only for individual cases of university-industry collaborative programs (e.g., Reddy and Rabins, 1984). It is clear that there is a great gap in knowledge about midcareer reeducation in engineering and its effects on jobs and careers.

FINDINGS

1. A meaningful body of knowledge has begun to accumulate regarding continuing education from the perspective of the engineer, but most of it is derived from studies conducted prior to 1980 with support from the National Science Foundation. Whether these results are applicable to current conditions in engineering cannot be ascertained. (For example, the expanded use of computers and video-based delivery systems in current continuing education offerings might affect some of these results.) This caveat should be kept in mind when reviewing these findings.
2. Engineers participate in continuing education with a variety of objectives; typically, these may involve maintaining and improving job performance, preparing for increased responsibilities, pursuing advancement and rewards, promoting intellectual stimulation, preventing obsolescence, or preparing for a new job. Relatively little is known about the role of the work environment in motivating continuing education participation.
3. Major barriers to participation in continuing education include the travel time involved, the inconvenience or unavailability of needed courses, and personal commitments the engineer considers more important. Organizational factors (e.g., a particular job does not require continuing education; there are no organizational rewards or encouragement by supervisors) appear to play a secondary but still important role.
4. All the available evidence indicates that most engineers participate in continuing education at some point in their careers and that the rate of participation has been growing. It would appear that by the early 1980s over half of all engineers were participating in some type of annual continuing education with employer-sponsored in-house courses predominating.
5. Participation in continuing education varies substantially with the size and location of an engineer's employer. Those engineers who work in small, geographically isolated firms show only limited continuing education participation, primarily involving activities offered away from their firms.
6. Employer tuition support has been the most important source of funds for continuing education among engineers, although much of this support is used for graduate education. Such assistance is prevalent in the overwhelming majority of large urban firms; most small nonurban firms do not provide it.
7. The evidence appears to be too limited to arrive at any conclu

sions regarding the impact of continuing education on the individual engineer; despite the enormous resources allocated to it, relatively little is known about its effects. The studies that do exist give results that are not generally consistent and that may, in some cases, have methodological flaws.

RECOMMENDATIONS

Considering the dated information noted above on continuing education for engineers, the panel believes the following recommendations are appropriate to close the gaps in our knowledge:

1. The National Science Foundation (NSF) should resume its role in supporting research and development (R&D) in continuing education.
2. A committee should be established within NSF to assist in the development of continuing education support activities. Its members would include continuing education researchers and practitioners selected from universities, private industry, and professional societies.
3. A comprehensive continuing education R&D program should be developed with the active participation of the federal government, academia, industry, and professional societies. This program should be directed to collect current descriptive data on continuing education participation and to study its impact (including that of reeducation programs) on the engineer.

3

The Role of Industry

In reviewing the role of industry in the continuing education of engineers, it becomes important to define the kind of continuing education that is involved. The continuing education process should not be considered synonymous with continued learning; rather, it is merely one part of the continued learning process. Also, it is not necessarily all of the education an engineer receives while an employee because many individuals continue their learning in a variety of directions. Continuing education, then, must be associated with the education and training used to provide knowledge and skills that keep engineers productive in their fields. (Whether to include in this definition advanced degree programs, in which one may enroll after finishing formal education and entering industry, presents something of a quandary. Some education of this type meets the criteria for continuing education, and some is intended strictly to complete a formal process of education.) In this chapter the panel is more concerned with the use of continuing education by industry to enhance the engineer's ability to contribute: by promoting creativity, by preventing obsolescence in an era of technological change, or by imparting new skills so that the engineer becomes more flexible and can contribute in areas of need. In short, the purpose of continuing education is to develop an engineer's problem-solving abilities.

A basic goal of this study (see the continuing education model in the Introduction) was to determine the extent to which continuing education can play a role in increasing the productivity of engineers in indus try and thereby provide the nation with more cost-effective technical resources. A report from the Massachusetts Institute of Technology (MIT) (1982) confirmed the importance of this role and concluded the following:

- The future vitality and competitiveness of U.S. high-technology industry depend on widespread acceptance of lifelong formal educational activities as integral components of productive engineering work.
- Providing appropriate lifelong educational experiences for engineers at the workplace requires close collaboration among engineering schools, industry, and professional societies.
- The development of lifelong education for working engineers and the creation of the necessary supporting environment at the workplace will require the leadership and personal attention of top executives in industry and in academia.

The study was conducted by a group composed of representatives from both industry and academia. It is often quoted when continuing education for engineers is discussed and has, in a way, become the support on which new continuing education efforts are being built. The study's recommendations, directed to the engineering community and to MIT's Department of Electrical Engineering, included the suggestion that industrial organizations take positive steps to encourage and support formal study on the part of all engineers, whether working at the bench or managing large projects.

Other documents testify to the value of continuing education. For example, Biedenbach (1978) states: "Over the past decade, continuing education has become vitally important for everyone in any engineering field." He goes on to say that although most people say they learn best on the job, this may not necessarily be the case. Houle (1972) refers to education as "a way of life for most medium and large companies in the United States. " A study by the Mitre Corporation (Troutman, 1978) estimated that more than $1 billion was being spent annually on employees' technical education and training. The American Society for Training and Development (ASTD) estimates that in 1983 industry spent about $30 billion and government about $10 billion for all training and education. (While these estimates confirm that a great deal of money is spent on these activities, the huge disparity between them—notwithstanding the five-year time lag—illustrates the difficulty of accurately assessing the amount. The main problem appears to be differences in the ways such data are reported.)

INDUSTRIAL CONTINUING EDUCATION PROGRAMS

Most large U.S. companies do have continuing education programs. It is very difficult, however to determine the extent to which the programs fit the definition discussed above for continuing education of engineers. Furthermore, because both universities and industry define continuing education to fit their own perceptions, it is virtually impossible to estimate the costs or effectiveness of these programs. R. A. Svenson & Associates, Inc. (1983), conducted a major study for the American Society for Engineering Education of the extent to which performance-based objectives are being used in industrial training programs and the benefits of such programs. The study team interviewed 13 companies, 5 in person and 8 by telephone. The interviews covered the historical aspects and organizational structure of the programs at the various companies, as well as their nature and extent. The report contains the results of these interviews. One conclusion that can be drawn from the data is that companies' programs and their goals vary greatly, although there is common agreement that training must improve job performance and be efficient and flexible.

Types of Programs

Significant company programs of continuing education for engineers that have been reported in the literature are discussed below.

The Mitre Corporation (Troutman, 1978) is a not-for-profit contract research center that works solely on government contracts. To meet its telecommunications goals, the corporation developed an in-house program to teach systems engineering. The program used a broad systems approach that included problem solving and case studies. It was conducted during working hours and integrated six learning areas: the systems process, human communications, user considerations, technology, nontechnical factors, and trade-off skills. This approach was designed to develop such skills as managing all or parts of the systems engineering process, handling the various resource roles on a systems team, presenting ideas orally and in writing to management and associates, listening, evaluating, reading, and abstracting effectively, and dealing with all kinds of people.

As reported by Grassl (1976), Siemens has developed a worldwide continuing education program that in the mid-1970s consisted of 5,000 courses in which 50,000 employees participated. Two-thirds of the company's 300,000 employees are located in West Germany.

At the Lawrence Livermore Laboratory, an industry-like facility, Cassell (1976) reports that the continuing education program has two major goals: to provide opportunities for each individual to maintain competence in scientific and technological areas, and to provide the stimulus that will enable engineers to remain creative in their contributions to the laboratory programs. Instructors are chosen from the engineering staff in specific subject matter areas. Originally, students were drawn from the ranks of more mature employees whose degrees were 10 to 25 years old. The program includes courses presented by employees and designed specifically to meet laboratory needs, offsite courses in specialized technical or administrative areas, degree-seeking university courses at either the graduate or undergraduate level, conferences or seminars, and specific learning assignments.

The laboratory program emphasizes planning for educational goals, and these educational plans are usually based on performance in the present assignment, job expectations, interest of the individual, and the needs of the laboratory. The program is linked by television to three major California campuses (Davis, Berkeley, and Stanford), and students are permitted a maximum of six hours off per week to pursue educational activities. Career planning sessions and workshops are also held to help both employees and departments establish reasonable and achievable goals.

Koves (1976) reports on the continuing education program of the IBM General Systems Division at Rochester, Minnesota. He makes the point that continuing education has been part of the IBM organization since its beginning. Most of its educational programs are organized on company time, and the corporation is committed to providing an environment that supports personal growth and learning, which includes discussion programs such as the familiar Great Books course. In addition, the Systems Research Institute, in New York City, offers graduate-level education programs in the computer sciences. Its major objective is to provide qualified employees with a graduate-level program to meet the current and future personnel needs of IBM.

The local Rochester program is an advanced study program designed to increase knowledge and maintain a high level of technical competence through courses. Special programs include a course entitled "Analysis of Great Ideas," part of the Great Books program. Also included is a two-week concentrated course for engineering managers on modern technical concepts. Its aim is to revitalize the manager's technical knowledge, as well as bringing him/her up to date on the newest advances in technology.

Burgwardt (1976) reports on the use of individualized instructional systems at Xerox and claims that these systems provide more flexibility for learning.

The continuing education program at Bell Labs was described by Wischmeyer (1976). According to Wischmeyer, continuing education in the research and development environment is simply learning that is organized in ways that best support the practicing professional in keeping abreast of the latest technological advances. It is education that takes place after the attainment of the highest degree. At Bell Labs, some of the objectives of continuing education include antiobsolescence, professional growth (to correct any "blind spots" in an engineer's traditional background), increased technical breadth, career redirection, and technical renovation. The faculty for the Bell program is drawn from its own personnel—those currently working in the areas being taught. The long-range student body does not change.

Yamada (1979), in describing the continuing education philosophy at Hitachi, states that continuing education provides the ability to implement creativity, as well as to simply absorb new technologies. The program is based on the following precepts: social trust, pursuit of the highest technological levels, and strong team spirit. The curricula are designed to impart engineering, philosophy, science, and other relevant knowledge. The formal training sequence includes prestudy by correspondence; classwork, homework, and case studies at a laboratory location; and follow-up every two years thereafter.

The aim of the Hitachi continuing education program is to promote creativity by elevating, broadening, and refreshing. Participants are both junior and senior engineers of the Hitachi group; their average age is 35. The program is comprehensive and includes both technical and nontechnical skills. The classroom time is initially four weeks, followed by three days every two years.

An in-house program at Exxon Research and Engineering Company was described by Hofstader (1983). The program provides employees with graduate level education in technological areas of interest to Exxon's overall business. It is interdisciplinary in that it integrates the various sciences and engineering technologies into curriculum areas. The program includes a relationship with Columbia University, which offers graduate degree credits for certain courses developed as part of the technical education program. The courses in the Exxon program have been developed internally and are designed to meet the needs of employees at all levels of the technical population. The major goals of the program are to reinforce individual growth and catalyze the development of new technology. All courses are offered on company time.

Texas Instruments' continuing technical education programs have been designed for the specific benefit of employees with at least 10 years of service with the company. The courses were selected to expose these employees to subjects that were not generally taught 10 years previously. In this sense, the effort is a renewing program as much as it is a continuing program.

Goals and Assessments

Company education programs vary from those that have been totally developed internally to those that depend solely on outside courses. Based on the goals and objectives of the programs, each scheme has merit, but it is difficult to compare them by means of any objective measurement. It is evident that no standard goals for continuing education have been developed by industry. With objectives as broad as individual growth to those as narrow as being sure that every member of a staff becomes familiar with a specific computer language, it is no wonder that it is difficult, at best, to assess with any validity what is going on in continuing education.

More important, perhaps, is determining whether any of the programs are really designed to meet the goals of lifelong education for engineers, to be effected through the cooperation of industry, academia, and professional societies, as called for by the MIT study (1982).

UNIVERSITY/INDUSTRY INTERFACES

Many continuing education programs are a direct result of university/industry interfaces. Goel (1978) described a program developed at the School of Advanced Technology, State University of New York-Binghamton, to help industrial scientists and engineers remain up to date in a rapidly changing technological environment. The modular program, called Comet (Concepts of Modern Engineering and Technology), is a 10-day course focusing on concepts and applications in which 30 topics are covered by 20 authorities. These topics fall into the following categories: technologies with future impacts; updating of active technologies; "soft" technologies for problem solving, modeling, and decision making; and cultural topics that may not be directly relevant but are important to the development of the "whole" person. The Comet program was used as the "starter," but several other courses followed, based on identified needs, and a hierarchical approach was developed.

Other universities across the country have also developed relationships with industries and provide general, as well as specific, programs to meet their needs. Technology, especially in the form of video, has been a major contributor in bringing education from the university to industry. And programs at most major universities permit employees to obtain advanced degrees and continue their education at the work-place. These programs have grown by leaps and bounds during the past several years, even to the extent that degrees will be obtainable by taking a variety of these courses from several universities through The Association for Media-Based Continuing Education for Engineers, Inc. (This organization is described later in the section on the universities' role in continuing education.)

EFFECTIVENESS OF CONTINUING EDUCATION

There is little doubt that continuing education offers a direct payoff to industry, but measuring its effectiveness is difficult. Part of the difficulty is the absence of clear objectives against which to measure accomplishment. Several studies have addressed the question of the relationship of job performance to the time spent in continuing education.

A major study by Genesys Systems, Inc. (Morris, 1978b, 1979a,b), surveyed personnel from four large engineering firms to study the relationship between continuing education and job performance. The study involved 396 engineers who participated on a voluntary basis. Overall, the results indicated that continuing education is related to job performance and that both management courses and technical courses led to higher earnings, with technical courses having the greatest impact. A slight negative correlation was found, however, between participation in technical courses and progression in management. Because this study looked at the engineer directly, the goals of the individual were being studied, as opposed to the goals of the employers.

Kaufman (1978a) conducted a longitudinal study of the relationship of participation in continuing education to job performance of 110 engineers in three different organizations. His data show that the number of graduate-level courses taken early in a career strongly related to job performance in research and development environments only. Engineers with poor performance enrolled to a greater degree in in-house courses, but there was no relationship to subsequent job performance.

Both the Genesys and Kaufman studies addressed the performance of the individual and not the performance of the organization. Although individual achievement, as determined by recognition and compensation, should correlate with organizational performance, it is only a part of the organizational performance measure, a part that is at best difficult to assess in terms of the value of continuing education.

Yamada (1979) described an interesting procedure developed at Hitachi for evaluating the effectiveness of the company's internal continuing education programs. The process uses questionnaires to measure program effectiveness against the following seven objectives:

- Augment the respondent's ambition to learn in the future.
- Acquire basic knowledge and engineering technology.
- Recognize the relationship between the respondent's field and other fields of engineering.
- Provide information on the availability of experts and literature.
- Apply the knowledge gained in the course to the respondent's current job.
- Suggest future job assignments.
- Clarify important points in the respondent's current assignment.

Organizational effectiveness can be measured in terms of the cost of labor for a given revenue level. If reduced labor cost is a measure of technical competence, then the cost of achieving that competence (through continuing education) should be no more than the reduction in labor cost. Kendrick (1983) has proposed that productivity gains in the United States during a 25-year period are the result of improved resource allocation, capital utilization, economies of scale, advances in knowledge, and labor quality or education/ training. Education represented about 25 percent of the total improvement. The average industrial productivity gain during this period was 2 percent per year. Therefore, an investment in training and education by industry of at least 0.5 percent of payroll could be justified. In fact, most large industries invest 1 to 5 percent of payroll.

The effectiveness of preemployment education in the engineering colleges is monitored by the Accreditation Board for Engineering and Technology. There is no comparable board for continuing education. However, the Council for Continuing Education Units developed in 1984 a proposed set of standards for continuing education, entitled *Principles of Good Practice in Continuing Education*. Adoption of this proposal could be a major step toward increasing the effectiveness of continuing education.

This chapter has presented some of the generally held beliefs about industry's role in continuing education and its role in shaping the future of modern engineering technology. Current developments in continuing education in specific industries, the relationships developed between industry and universities to provide continuing education, and some attempts to measure effectiveness have also been discussed. In each case the major conclusion is that without clearly articulated goals for what industry wants, needs, or expects from continuing education, the true value of the programs will remain nebulous at best. No doubt goals such as retraining or teaching a new computer language or skill can be met. But even in those cases the question remains: Are the objectives being met in the most cost-effective manner? Where continuing education is intended to increase the productivity of the engineering force, an assessment of its effectiveness becomes more difficult. The panel decided, therefore, to determine how corporate leaders who have already subscribed to large continuing education programs within their companies view some of its values and how they see their educational programs being integrated into the corporate culture in long-range and short-range business plans.

THE PILOT STUDY

The model used for continuing education in this report (see Chapter 1) describes the process of need being translated into a more effective career. But the question must be asked: Do corporate leaders see this need, and are they willing to support continuing education to satisfy it?

To explore this issue, the panel engaged a consultant, Dr. Robert Boruch of Northwestern University, to develop a pilot survey that would help assess the attitudes of corporate leaders as to the value of continuing education programs and how these programs are affected by strategic planning, engineering expertise, and companies' productivity, competitiveness, and capacity to innovate. A large survey was beyond the scope of this project, so the panel sampled 20 companies in a pilot study. Company training personnel interviewed the corporate leader—if not the chief executive officer, then another appropriate individual, chosen by them. This approach yielded an added benefit in that the person responsible for developing the training program would be in a position to discuss training strategies directly with the corporate leadership. The interview guidelines appear in Appendix A of this report.

Although the sample is small, it includes leaders in continuing education in industry. Considering the responses in that light, rather than as representative of the views of a large group of companies, the following statements can be made:

- Virtually all policymakers in continuing education have technical backgrounds and most are long-term employees. These characteristics, they say, influence their views about continuing education.
- All respondents recognize technical change in strategic planning. Most do not incorporate continuing education explicitly into planning

but depend on personnel decisions to do so. Concern about the technical currency of company engineers is clear. The degree of concern depends on the availability of young engineers, on the particular functional area, and on the extent of the respondent's perception of the entire spectrum of development to marketing as a technical issue.

- About half of the respondents believe the company's productivity can be influenced by continuing education; about half say that competitive position clearly can be influenced by it. The remaining respondents cited other factors as being more influential.
- All respondents believe continuing education can influence innovativeness. But some are cautious, maintaining that innovativeness itself cannot be taught. Rather, continuing education provides the tools, and the opportunity to innovate depends on the area.
- "Typical career" paths are clear in only a third of the responding companies. Regardless of whether typical paths can be identified, about two-thirds of the respondents say that the path is primarily a mutual responsibility of the company and the engineer. One-third leaves it mainly to the individual. Most said that no changes are envisioned.
- Most companies have incentive programs to encourage continuing education. But the incentives mentioned—e.g., tuition reimbursement —were unremarkable. (Some may even argue that tuition reimbursement is not an incentive.)
- Other issues that are salient for these respondents include the quality of the technical support staff for engineering. Continuing education for the technical support staff may be a factor in engineering productivity.

FINDINGS

1. Policymakers in the pilot study were equally divided on whether continuing education is a major influence on productivity and competitiveness. They were unanimous in their view of it as an influence on innovation.
2. Though change in technology is recognized in strategic planning, according to the results of the pilot study continuing education is not recognized explicitly at the corporate policy level.
3. The continuing education programs that seem most successful are those that are developed with a clear commitment to the company's objectives.
4. Industrial programs vary in size, type, and complexity and display no consistent pattern. Each program responds to the company's particular needs.

5. Methods of evaluating continuing education programs are not consistent and have not been designed to examine the benefits that accrue to the company. Those reported in the literature examine only the benefits to the individual. The lack of clear-cut objectives for the program makes evaluation difficult. For example, in meeting objectives, no clear distinction has been made between graduate degree programs and continuing education.

RECOMMENDATIONS

1. Research must be initiated to develop tools for linking continuing education to the performance of engineers and for evaluating the impact of continuing education programs on the competitiveness of the organization.
2. Companies should set clear objectives for continuing education based on business plans.
3. Professional societies and other influential groups should cooperate in programs designed to make corporate policymakers more aware of the value of continuing education to their companies.
4. Industry and academia jointly should define their respective responsibilities in and support approved standards for continuing education.

4

The Role of the University

Continuing education generally is taken to mean formal courses that are not intended to lead toward a degree. Even though credit and degrees are not the primary objectives of continuing education courses however, one would expect to find universities playing a major role. They have faculties and facilities; they are also responsible for the undergraduate and graduate education of engineers. Because continuing education courses build on this educational base, it is reasonable to expect that almost all universities will have significant activities in continuing education. But this is not the case. Except for a dozen or so universities with large, well-organized extension programs in urban centers, most institutions use their resources for undergraduates, graduate students, and research. Nevertheless, this section describes the characteristics of university-sponsored continuing education for engineers and presents several recommendations on its future role.

TYPES OF PROGRAMS

Academic institutions offer several generic types of continuing education programs:

- *Evening classes* meet on campus after dinner one or two evenings per week for 10 to 15 weeks. These courses may use regular textbooks or syllabi written by the instructor. The students are assigned reading and problems for homework and take examinations. In content the course may or may not be the equivalent of a regular course given by the university. In some instances, both regularly matriculated students and extension students are enrolled in the same course, which is then designated as concurrent.

- *Short courses* meet on or off campus (e.g., in a hotel) all day for 3 to 10 days. These courses often use a team of instructors. The subject matter is almost always very specialized, and syllabi are usually prepared by the instructors specifically for the course. In general the quality is high. Short courses have no homework or examinations, but the students may spend many hours outside of class reading the syllabi and they are encouraged to bring their problems to the class. Because the courses last for only a few days, students may come from a considerable distance and devote themselves full time to the course.
- *Television classes* are held in a studio, usually on campus, for transmission live to a remote location. (Sometimes, transmission from the remote location to the campus is also provided.) The program may be a "produced" or "candid" classroom. Homework and examinations are picked up and returned by courier. The instructor is available to the students by telephone, and the course content is the same as in courses being televised on campus. Auditors are normally admitted but may or may not be graded.
- *Videotaped classes* are similar to television classes. They are produced in the studio and delivered to the remote location, where they may be viewed at a convenient time by one or more students. Here, too, the students have access to the instructor during telephone "office hours," and homework and examinations are shuttled back and forth by courier.
- *Tutored videotaped instruction* is a popular variation of videotaped instruction. The tutor's role is to control the rate at which the material is presented and lead the discussion. To facilitate nationwide distribution of videotaped courses, a consortium of universities in 1976 established The Association for Media-Based Continuing Education for Engineers, Inc. (AMCEE). The membership has grown from the original 12 institutions to 23 members and now represents 90 percent of the media-based graduate and continuing education available to engineers.
- *Certificate programs* are planned sequences of courses, usually 6 to 10, leading to the award of a certificate in a designated specialty. The sequence of courses is usually determined by an advisory committee composed of representatives of the profession and the institution. The students are "qualified" for the program before taking the courses.

GOALS AND CHARACTERISTICS OF PROGRAMS

The basic goal of almost all universities, often explicitly mandated in the charter of the institution, is to educate undergraduate and graduate students; in addition, research universities foster research. Each institution also has more specific goals that relate to excellence in education and research. However, a university's specific goals for continuing education are usually not as well defined and often come under the heading of public service rather than education. One of the "publics" is the engineering profession, for which universities often provide professional courses. (Engineers also may enroll in courses in the arts, humanities, and social sciences.) But the institution has no mandate to serve the engineering profession and, as we shall see later, few incentives.

Whether planned for or not, an institution's continuing education programs influence its courses, research, and relations with industry. Even though the net flow of subject material may be from the credit courses to the continuing education courses, the latter contribute to the credit courses. In addition, short courses provide a showcase for faculty research and often lead to consulting opportunities. Thus, continuing education programs serve as a bridge between industry and academia.

Although the variations are many, academic continuing education programs have some common characteristics. The students have a wide range of abilities, motivations, and preparation. They are mature and experienced and tend to be more critical of course content and instruction than regular students. Continuing education students are not compelled by degree requirements to finish a course they find boring or irrelevant. Many are at the midcareer stage. These students challenge the instructor, but teaching them can be a stimulating experience.

Faculty for continuing education courses are drawn from industry as well as the university. In fact, as a consequence of the shortage of regular faculty and insufficient incentives, the majority of continuing education instructors now come from industry. They are good classroom teachers because their reappointment is based on their teaching performance. Those from industry usually have the same academic qualifications as regular faculty but not the record of research achievements. On the other hand, they have a good feel for the applications of engineering research.

The content of a continuing education course is often drawn from one or more credit courses, but it is not as dependent on prerequisites and a complete understanding of the underlying theory. Many continuing education courses are quite mathematical, but the emphasis is more likely to be on relevant applications. The content of each course is reviewed and approved by the institution but to a degree that varies from one institution to another.

Continuing education courses are scheduled to accommodate the working hours of the students. Evening classes are after work, and short courses and videotaped courses are designed to minimize the time lost from the job. Whatever the schedule, however, it is likely to conflict to some degree with the student's commitments to the home, family, and self. Furthermore, the student may not be at peak alertness during continuing education classes.

Credit toward an advanced degree is an exception in continuing education courses. The majority of the students want information, not credit. But credit of some kind does facilitate the management of tuition-reimbursement plans. Thus, many institutions give academic or professional credit for their continuing education courses. Also, they may award continuing education units (CEUs) for satisfactory participation in a course. (Usually, one CEU is awarded for every 10 contact hours.)

Good study discipline is an important characteristic of continuing education courses offered by universities. It appears that the attitudes toward attendance and persistence developed by the student in undergraduate or graduate days carry over. The environment is similar, and the students take the university's continuing education courses seriously.

The continuing education delivery systems used by universities are the same as those used on campus. And the campus may be extended by television, videotapes, and electronic blackboards to serve small groups of students at remote locations. But technologically sophisticated delivery systems have by no means replaced the live instructor, chalkboard, and overhead projector.

At both private and public educational institutions, continuing education courses are self-supporting, with students paying the incremental cost. The large majority of engineering students are reimbursed by their employers upon successfully completing the course. (This practice contributes to the study discipline noted above.) Universities use the same facilities for both their continuing education and regular degree courses (although the use of such facilities sometimes inhabits innovation with delivery systems). Only at a few institutions have special centers been designed and built for continuing education. Each continuing education student takes fewer courses than a full-time student but requires as much parking space and other services, such as custodial help.

INCENTIVES AND DISINCENTIVES

Even though continuing education programs generate some revenue for the university, they are a drain on its resources and have a low priority. Providing continuing education courses is a service to the community; in these times, when all universities are developing additional sources of financial support, enhanced community relations are an incentive to offer such programs. But, on balance, institutions have more disincentives than incentives to provide continuing education programs. Almost the same can be said of faculty. They already have heavy teaching loads and earn less for teaching an extension course than for teaching a regular class or for consulting. Teaching courses at the cutting edge has obvious incentives, including faculty renewal, but the majority of continuing education courses are not at the cutting edge. Teaching extension courses carries little or no weight in the evaluation of the instructor's performance for advancement. Thus, neither the institution nor the faculty are strongly motivated to participate in continuing education programs.

The continuing education student can have many incentives. Such courses permit the engineer to perform better by gaining new insights, becoming aware of alternatives, and keeping up with rapidly changing technology. These courses also give the engineer a means of changing technical fields or preparing for greater responsibilities, such as those of management. The potential personal gain is so great that one may wonder why all engineers are not enrolling in continuing education courses. Because, in fact, the large majority (well over 75 percent) do not. What then are the disincentives? First, continuing education courses take time from other activities—the family, recreation, personal chores. Second, they cost some money, even if the major portion of the fees is reimbursed. The student must pay for supplies, transportation, and meals. Third, they often present inconveniences. Fourth, hard work is required by many continuing education courses. Finally, even though studies have shown that continuing education is recognized by the employer, pay raises and promotions are not given automatically or based solely on the completion of such a program. Other rewards for the effort made are not always immediately visible to the employee. And, further, the courses often do not have clear objectives that are job related.

FUTURE TRENDS

Continuing education in the future will reflect trends on campus, but some innovations will be especially attractive. This is particularly true of innovations that accommodate great diversity among students and those that can be easily extended beyond the boundaries of the campus. The use of satellites to establish an interactive network is an attractive possibility. Self-paced learning and computer-assisted instruction using microprocessors are examples of teaching methodologies that are particularly well suited to the working engineer. And the use of interactive video disks is an example of new technology that produces a high-quality program, independent of its physical location.

The interdisciplinary nature of the content and the rapidly changing state of the art make the team approach a practical way to develop new continuing education courses. Representatives from industry make effective members of these teams because industry now recognizes that continuing education is a cost of doing business and not a fringe benefit. One way to strengthen the bridge between industry and academia would be to create the position of engineer/educator, an individual with significant responsibilities both as a practicing engineer and as a teacher. Teaching duties could include course development, instruction both on and off campus, and working with graduate students. Several such individuals within an organization could truly extend the campus of the affiliated university.

Finally, there is the prospect of coalitions. Campuses tend to be provincial, but beyond the boundary of the campus are many attractive possibilities for joint endeavors, such as The Association for Media-Based Continuing Education described earlier. Universities and industry working together could provide better continuing education at lower cost.

FINDINGS

1. Continuing education has a low priority in the large majority of universities.
2. Neither the institutions nor their faculty have significant incentives to participate in continuing education programs.

RECOMMENDATIONS

1. Universities should reexamine the priority of continuing education programs for engineering in light of their role during the coming decade and then make a commitment to meet their responsibilities.

2. Academia should work closely with industry in developing clear objectives for the continuing education of engineers.
3. Because of the need to exploit new educational technologies to accommodate the great diversity among students, to extend the boundaries of available classes, to respond rapidly to changing technology, and to control the costs of continuing education, industry should assume the responsibility (from the universities) for the continuing education of engineers.

5

The Role of Professional Societies

No study of continuing education would be complete without discussing the activities of professional societies. Since World War II, these societies on the whole have become a major, highly efficient means of technology transfer. To place them in proper perspective relative to the continuing education of engineers, representatives of nine societies met in New York on January 31, 1984. The groups represented were:

American Association for the Advancement of Science (AAAS)
American Association of Engineering Societies (AAES)
American Chemical Society (ACS)
American Institute of Chemical Engineers (AICHE)
American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME)
American Society for Metals (ASM)
Institute of Electrical and Electronics Engineers (IEEE)
Society of Automotive Engineers (SAE)
National Society of Professional Engineers (NSPE)

Discussion centered on the following:

- the role of professional societies in continuing education;
- their means of listing current continuing education programs and the effectiveness of such means;
- the gathering of program statistics;

- the determination of current gaps in fulfilling members' needs; and
- the future thrust of societies in meeting members' needs in a world of rapidly changing technology.

The group generally agreed that the professional societies fill an important role in meeting the continuing education needs of the engineer. In many cases the societies provide the only mechanism available to engineers for remaining up to date after completing their formal education.

It was agreed, however, that several gaps exist in the societies' programs, that these gaps need to be defined, and that efforts should be begun to fill them. One of the readily apparent issues is that a number of societies that do not recognize the need to develop alternative education plans for their members and to provide the educational modules and programs necessary to carry out these plans.

It was also agreed that most professional groups have a two-tier age profile, a characteristic that affects continuing education offerings. Older engineers are knowledgeable, but they are not readily adaptable to new trends in technology. Also, because these people hold the power positions in the society's structure, changes in programs do not come easily. The younger age group, on the other hand, tends to lack the motivation and the means of taking part in continuing education programs, though it may recognize in itself the personal need to do so. Such programs, therefore, must be designed both to motivate the older group to adapt to changes in methods and to make it possible for the younger members to participate in them.

Clearly, professional societies can do more to anticipate trends in technology and build them into continuing education programs based on modern delivery techniques. While conventional delivery methods (e.g., conferences, proceedings, courses, and trade shows) will continue to be necessary and useful, newer methods such as video and audio courses, program tapes, teleconferencing, and the like must be accepted and used to broaden the base of participation in continuing education of members of professional societies.

CURRENT PROGRAMS

Over the past 20 years, professional societies' use of conventional continuing education programs and delivery systems has grown phenomenally (Appendix B). Cooperative efforts with industry, academia, and government, and also with each other, have increased as well.

Depending on the engineering, scientific, or professional group, and on the technology or the industry, continuing education/professional development programs, both over the long and short terms, have been provided through conventional systems such as the following:

- conferences and clinics (in depth);
- formal courses (onsite) and home-study courses;
- books, proceedings, technical profiles, briefings, tapes, newsletters, etc.;
- combined hands-on trade shows and conferences;
- multidisciplinary conferences and group discussions; and
- industry-oriented in-house training programs.

The method of development of continuing education subject matter for engineers varies with its source. Examples of such sources include the following:

- industry—driven by critical needs;
- standing committees' recognition of changes in technology and engineering and, therefore, in the needs of peers;
- discipline-oriented special committees;
- multidisciplinary and multisociety groups;
- academic, governmental, or industrial R&D grants and outputs; and
- targeted basic scientific or applied individual or joint research projects.

Although these six sources provide the bulk of continuing education programs, they are augmented by various forms of cooperation involving professional societies, industry, academia, and government.

Motivation for growth in the continuing education/professional development programs sponsored by professional societies takes several forms:

- industrial needs—short and long range;
- technical development of individuals beyond the completion of formal education;
- recognition of individuals for participation by means of plaques, certificates, awards, etc.;
- formal professional development and certification programs; and
- achievement of positions of responsibility in academia, peer groups, government interface groups, etc.

The societies use various methods to recognize accomplishment in continuing education. The CEU (continuing education unit), for exam ple, measures simple participation; the CEAU (continuing education achievement unit) implies or states prior peer evaluation of the content of the continuing education offering.

In addition, a number of societies provide central registries of individual accomplishment. For example, the Society of Manufacturing Engineers, IEEE, and NSPE offer the capability to record and document an individual engineer's educational progress, much as the college transcript does. These methods are a decided benefit to the individual and to industry.

These cooperative efforts and methods of motivation should be continued and greatly expanded. Because they require the use of tremendous financial resources, and the programs should be self-sustaining.

DEVELOPMENT OF STATISTICS

Professional societies have substantial amounts of data on their continuing education/professional development programs. At the meeting in January 1984, survey data were provided by SAE (a general survey now being expanded and updated) and IEEE (the results of a professional development program in 34 constituent societies). Results of similar surveys were to be provided by ASM and others present.

The group generally agreed that another questionnaire was needed to supply some of the statistical dimensions required for this report. Besides the general conventional statistics (e.g., conferences, programs, and attendance), the panel sought the following information:

- profile analyses of member groups to which programs are directed;
- how member needs are determined;
- how industrial needs for engineering knowledge are determined;
- data on how well needs are being met;
- data on programs within industry, academia, professional societies, and government;
- future trends in technology and the economy;
- listings of gaps in societies' programs, their seriousness, and contemplated corrective measures;
- evaluation of the adequacy of present delivery systems for members; and
- plans for programs to make cost-effective use of newer delivery technologies (e.g., teleconferencing via satellite, video/audio tapes, mobile teaching units, computer-assisted education, and computer home instruction).

Despite the studies that have been done by some societies, the group knew of no attempt to develop comprehensive data on society continuing education programs, members' needs, focuses, future trends, and other such topics. Earlier in this report, three societies were mentioned as making initial attempts to do so. Although time was limited, the group felt the need to update, in a limited fashion, the data available. A questionnaire was developed using the simplest of questions and the easiest format and sent to approximately 40 societies. Eleven societies responded; the results appear in Appendix C. They confirm these trends:

- a widespread increase in the number of conventional programs and attendance at them;
- growth in the number of societies with technical committee structures charged with discerning leading-edge technology and presenting it to members and nonmembers alike;
- greater attention to member profiles, needs, and professional development;
- shorter lead time for program development;
- almost universally advancing technology in the areas served by each society;
- a move from parochial interests to widespread recognition of the need for multidisciplinary and multisociety approaches to program development;
- greater attention to formal professional development, continuing education, and certificate and accreditation programs;
- an indicated effectiveness of member, individual, and group recognition programs; and
- an awareness of the need to modernize delivery systems to make continuing education more rapidly and thoroughly available to greater numbers of members.

PROFESSIONAL SOCIETIES TODAY

Much of the content of this report was already known or suspected by the members of professional society staffs who met in January 1984. All of them are intimately concerned with professional development, continuing education, and the necessary program development and delivery. It is their consensus that this study is only a beginning and that much more needs to be done, starting with a large comprehensive follow-up study.

Professional societies are heterogeneous bodies comprising academics, scientists, engineers, technicians, industry leaders, and govern ment workers. These types of individuals are now involved in all of the societies, and they are learning to appreciate and understand each other's needs, knowledge, and viewpoints and to work together for their common learning and advancement. Government and industry have given long overdue recognition, support, and cooperation to professional societies. One need only look at the increased professional input to governmental processes and the growing number of individuals supported by industry both for membership in professional societies and attendance at their programs to understand the substance and extent of this recognition.

FINDING

Professional societies today differ from those of 10 years ago—they are modern, aggressive, and abreast of technological change. Nevertheless, although these organizations in recent years have sharply expanded their efforts in continuing education, they could do much more in designing and presenting professional development programs to their members. A major difficulty in doing so is the lack of solid information on members' needs, the extent of current activities, and similar points.

RECOMMENDATION

A focused, integrated study should be made of activities and needs in programs of continuing education developed by professional societies. Particular emphasis should be placed on: (1) early warning of technological advances by the modern means of quick delivery of continuing education; (2) computerization of member profiles and technology data banks; (3) knowledge of the extent of multidisciplinary and multisociety cooperation in program development and delivery; (4) less costly and more efficient program development and delivery; and (5) the extent of society, academic, industrial, and governmental cooperation in raising the level of professional competence.

6

The Role of Proprietary Schools

There are some private, entrepreneurial organizations that provide continuing education and that have been in existence for many years. These are the proprietary schools. Others have recently entered the field, recognizing a need for continuing education among engineers and managers, and the possibility perhaps of a "gold mine." Their programs typically are relevant, though high priced. Because of their topical nature and popular appeal, they are generally financially successful.

Programs are offered at convenient times and locations, and the instructors are generally very good. Because of their brevity, these courses do not seriously interfere with the professional commitments of working engineers. The overall educational effectiveness of the courses is somewhat indeterminant, however, because engineers generally attend them based on the reputation of the offering organization.

Klus and Jones (1978b) report that approximately 10,000 engineers are participating in private entrepreneurial technical courses at any given time. In a survey of career development activities of 87 companies that subscribe to *Research Management*, Thompson and Drake (1983) found that 47 percent employed private entrepreneurial training courses as a career development medium. Overall, proprietary programs ranked seventh of fifteen strategies reported.

Information on proprietary programs actually is quite limited, however. In the face of all that has been developed on the efforts of industry, academia, and professional societies in continuing education, there is no known body of knowledge that addresses the size, scope, or cost of continuing education programs conducted by private operators. The American Society for Training and Development (ASTD) has identified an initial undertaking in this area, by Hope Reports, Inc., a consulting firm that publishes reference material relating to training activities of commercial firms, associations, and institutes.

According to a 1984 survey, a conservative estimate of the size of the proprietary training industry would be $2 billion annually, including off-the-shelf, custom-designed, and generic services. An estimated 3 percent of the total, or $60 million, is spent annually on these latter programs. These figures, as well as enrollment data, must be assumed to be extremely conservative estimates. That they are all that can apparently be developed from available research suggests that additional study of the proprietary segment of the continuing education universe is in order.

A final point of interest is ASTD's estimate that proprietary programs grew at an average annual rate of 7.5 percent during 1978–1982. Conversely, spending on proprietary programs dipped 2 percent in 1981–1982, suggesting that short courses are the first element of continuing education to be sacrificed during cost-cutting periods.

7

The Role of Government

Public policy directly influences continuing education. This chapter will address legislative trends that are directly related to the shape and direction of continuing education of the engineer in the United States. Comparative national policies will then be reviewed to place U.S. public policy in some perspective. Finally, the federal government's role as a provider of continuing education will be examined.

MANDATORY REQUALIFICATION

Most nonindustry engineers in all states must be registered to practice their profession. Those in favor of continuing the proof of competence say their purpose is basically to ensure the quality of products and services provided by engineers. Many engineers, however, detect in such statements the first steps toward a profession totally regulated by a government bureaucracy.

About 25 percent of the states have become involved in activities focusing either on repeal of the industry exemption to engineering registration laws, as in Montana, or on laws mandating continuing education, as in Iowa. In addition, New Jersey and Wisconsin have voluntary professional development programs for registered professional engineers wherein credits are granted for activities such as college-level and short courses, seminars, inventions, technical society meetings, research papers, trade shows, and home study. These programs, together with the impetus for repeal of industry exemptions, are being backed by state affiliate societies of the National Society of Professional Engineers (Zimmerman, 1978).

Corresponding concern exists regarding the quality of continuing education programs. The National University Extension Association is on record as recommending that continuing education programs be subject to the same review process extended to other accredited collegiate activities (Burnett, 1979). The Accreditation Board for Engineering and Technology and several technical societies have studied accreditation or validation of continuing education programs for engineers (Atiyeh and Young, 1983).

As a result of the public debate in the early 1970s regarding the competencies of various professions, the state of Iowa established a legislative study committee. It was chartered to review a proposal that provided for legislative review of all professional and occupational examining boards and mandated continuing education as a condition of license renewal. On the basis of favorable findings, an act was adopted by the legislature and signed into law in July 1977.

In 1979 the Iowa State Board of Engineering Examiners (ISBEE) adopted administrative rules defining qualifying programs, the continuing education unit, and the annual requirements for license renewal. The ISBEE does not, however, prequalify programs. So long as the activity is determined by the engineer to contribute to his or her professional competence, and so long as it has a clear purpose and objective and is well organized, planned, and presented by qualified instructors, it is deemed appropriate.

The ISBEE rules defined the professional development hour (PDH) as the unit of continuing education. Initially, full-time practicing engineers were required to complete 15 formal PDHs and 25 informal PDHs annually. Nonpracticing engineers were required to complete 30 formal and 25 informal PDHs. In 1983 the informal professional development requirement and the distinction between full-time and nonpracticing engineers were dropped.

A report documenting continuing education is prepared annually in Iowa, as is a random audit of registrants. Results of the 1981 (first-year) audit of 1,007 registrants showed the following:

- 75 percent noted that courses meeting their needs were available,
- 93 percent reported release time wholly or partially provided,
- 87 percent received full or partial reimbursement,
- 80 percent indicated a suitable opportunity to obtain continuing education,
- 55 percent perceived or expected improvement in the profession,

- 60 percent perceived no change in public perception of the credibility of professional registrants,
- 48 percent noted improvement in their professional capabilities, and 12 percent more expected improvements, and
- 50 percent of industry respondents perceived no improvement in competency.

Because of the enactment of the law and the initially more stringent continuing education requirements for nonpracticing engineers, the number of active registrants declined significantly, from 5,180 in 1980 to 4,356 in 1982. The same period saw a concomitant increase in the number of inactive registrants, from 175 to 731. The 1983 report indicates an apparent stabilization, with growth in the number of active registrants to 4,676 and maintenance of 731 inactive registrants (Ring, 1984).

COMPARATIVE POLICIES

Mintzes, in his comparative study of technical personnel trends and competitiveness in the United States, Japan, West Germany, and France (1982), concluded that "industry, with government encouragement, is more involved in upgrading obsolescent skills of older scientific and technical personnel abroad than in the United States." France and West Germany have laws requiring periodic formal retraining, and the lifetime employment policies of the larger Japanese firms generate the same result. Although considerable training takes place in the United States, this country has no systematic policy for upgrading the skills of older workers.

In general terms, political structure and tradition exert a heavy influence on program design. Socialist countries tend to be highly organized and to develop programs financed directly or indirectly by the government. One result is an additional focus on course quality. In capitalistic countries, free markets lead to a focus on the analysis of needs.

National economic and development policies also influence the growth and components of continuing education. Developing countries characteristically assign higher priorities to the continuing education of teachers and technicians than to that of engineers. Moreover, courses are structured "away from traditional disciplines toward areas such as mining engineering, public works engineering, rural engineering, environmental engineering, and maintenance" (Klus and Jones, 1978a).

Virtually every country of the world has programs that subsidize the continuing education of engineers. The usual medium is employer subsidies, with instances of government financing and taxation in other cases. The shift from personal to employer/government responsibility is such that continuing education is increasingly perceived as a "right," in the manner of undergraduate education.

France enacted legislation in 1971 that created a 1 percent payroll tax for employers of more than 10 employees and established continuing education rights. The French experience is of some interest in regard to the domestic issue of mandatory continuing education and its impact on participation in continuing education. Specifically, Klus and Jones (1978a) report that the percentage of engineers and senior staff participating in continuing education in France decreased, from 19 percent in 1971 to 15 percent in 1975. Also, two surveys conducted by French engineering associations in 1970 and 1973 indicated a constant rate (56 percent) of participation in continuing education. Klus and Jones conclude that "it is doubtful whether mandatory continuing education for licensees would have any positive effect on continuing education."

FEDERAL PROGRAMS IN CONTINUING EDUCATION

Federal civil service regulations provide for support by federal agencies of continuing professional development of engineers employed directly by the federal government. Support under these regulations falls into two major categories. One is support for federal employees' attendance at professional meetings and participation in other functions of professional and technical engineering societies. The other is support for employees' participation in continuing education activities, including technical seminars, short courses, and degree-producing courses. Continuing education programs include both those presented by universities and technical engineering societies and those presented by the federal agencies themselves.

The federal government's commitment of resources to continuing education of its engineering employees is probably very substantial. Unfortunately, however, the system is so decentralized that no reliable data are available.

FINDINGS

1. Currently, no governmental guidelines exist for accreditation or evaluation of continuing education programs.
2. Mandatory continuing education programs may have an adverse impact on renewals of professional registration.
3. It is doubtful that mandatory continuing education will have a positive impact on enrollment in continuing education programs.

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Appendixes

Appendix A

Pilot Study for a Survey of Policymakers' Attitudes Toward Continuing Education

The panel decided to investigate the attitudes of corporate policymakers whose companies had developed and implemented relatively large-scale continuing education programs. Because a large survey was beyond the scope of this project, the panel instead sampled 20 companies in a pilot study. The interview guidelines that were developed for this effort appear below in four "documents":

1. Information for Interviewers: Pilot Interview Protocol,
2. Pilot Interview Protocol,
3. Debriefing Questions for Interviewers,
4. Information for Policymakers (who agree to participate), and
5. The Pilot Survey of CEO Values—Questions and Answers.

See Chapter 3 for a discussion of the study's results.

DOCUMENT 1: INFORMATION FOR INTERVIEWERS—PILOT INTERVIEW PROTOCOL

This is a pilot protocol for interviewing policymakers about their values and attitudes pertinent to continuing education. The questions it contains are based on discussions of the National Research Council's Panel on Continuing Education and the Committee on Education and Utilization of Engineers. The Panel's interest lies in field testing the protocol to determine if a formal survey of values is feasible and will yield useful information.

A. The General Rationale and Approach

The main reason for considering a survey is that very little formal research has been done to assess values of CEOs and other policymakers on continuing education for engineers. The Panel believes that it is important to understand values and attitudes at the highest possible level of the organization. This pilot protocol is a first step in understanding how to produce unique helpful information that will augment other data on the topic.

The pilot study and this protocol are based on some working premises.

Continuing education here refers to formal courses of study of technical or nontechnical material, undertaken by the graduate engineer, to produce some benefit for the company. The course of study may be external to the company or offered in-house.

The target for interviews are chief executive officers or an executive with primary responsibility for policy and resources bearing on career development of engineers. It is especially important to the Panel that this level of general management, as opposed to human resources staff, be addressed.

B. The Interviewers' Role in the Pilot Test

The survey is a pilot in the sense that if information generated in a small survey is useful and helps to understand values in this arena, then a larger formal survey may be undertaken. The interview protocol and procedure will be revised in several respects on the basis of the experience of interviewers in this pilot study. The interviewers' experience in using this protocol is critical.

Suggestions about how questions may be sensibly improved, deleted, or augmented are of course welcome. And to facilitate the process, a set of "Questions for Interviewers" is attached. These debriefing questions for the pilot study can be addressed by phone or in writing, depending on the interviewer's preferences.

The information being requested in the protocol is not especially sensitive. Nonetheless, individual responses are treated as confidential by the National Research Council and will not be disclosed in identifiable form. The responses will be summarized in statistical form for analysis.

C. Rationale for the Questions

The protocol involves some "scripting," i.e., an introduction, for each group of questions. Interviewers should modify the script to suit their needs.

Items 1–4 are background questions. Item 4 is predicated on the idea that the CEO's values about education stem partly from professional experience.

Items 5 and 6 address the issue of how technical change and human resources development are recognized explicitly in *policy and planning* , on the assumption that such recognition is important at times.

Items 7 and 8 focus on the CEO's concerns about technical *obsolescence/ currency* of company engineers and his or her views of how important currency is in influencing company productivity.

Items 9–11 ask for the CEO's views on *whether and how continuing education can influence company productivity, competitive position, and capacity to innovate*.

Items 12–14 ask for CEO views on the company's role (versus the individual's role) in career development of the engineer.

DOCUMENT 2: PILOT INTERVIEW PROTOCOL

A. Background

1. Name of Organization* ______________________

   Title of CEO or Policymaker Interviewed ______________________

2. Name and Title of Interviewer ______________________

3a. Number of years policymaker in his/her position ______________

3b. Number of years policymaker with this company ______________

The early primary professional experience and training of policymakers at times shapes views of how professional skills are developed or maintained.

4. What, in your early professional experience or training, may shape your views on the topic?

____

____

* Note: Items 1–3 may be completed by the interviewer.

B. Long-Range Planning

Some companies' long-range plans focus special attention on technical change and on the role of continuing education in change. Others do not. The Panel's interest lies in understanding *your* views of the value of recognizing change and continuing education in strategic planning.

5. In particular, how are technical change and technical issues recognized *generally* in the company's long-range planning process? For example, are such issues ranked high in planning relative to, say, marketing or administration? Are they formally recognized in priority-setting, agenda, committees, and other aspects of planning?

____

____

____

6. Is continuing education of engineers for technological change incorporated into long-range planning? If so, how?

Explain:__________________________________

____

____

____

C. Engineers and Their Expertise

A variety of studies on technical obsolescence of engineers have been issued by universities such as MIT and by national commissions. Most maintain that obsolescence is a problem because of the rapid rate of technical and scientific innovation. Some do not.

7. How would you assess your concern with technical currency of the company's engineers?

Explain:__________________________________

____

____

If you have to summarize the level of your concern with currency of engineers' technical expertise on a scale from 1 to 5, how would you rate it?

1	2	3	4	5
Not a Concern				Very Concerned

8. To what extent do you believe that the *productivity* of the company's engineers depends on their technical currency?

Explain:____

____

____

If you had to summarize your belief about the claim that engineers' productivity depends heavily on technical currency on a scale from 1 to 5, how would you rate it?

1	2	3	4	5
Strongly Disagree				Strongly Agree

D. The Company and Engineers' Continuing Education

A *company's* productivity, competitive position, and capacity to innovate at times may be influenced by the continuing education of its engineers. But little is known about CEO, EVP, and other executives' views about this. The Panel would benefit from your views of each of the three issues.

9. To what extent do you believe that the *company's productivity* can be increased through continuing education of its engineers?

Explain:____

____

____

If you *had* to summarize the strength of your belief, very roughly on a scale from 1 to 5, how would you rate it?

1	2	3	4	5	Prefer not to rate_____
Do not believe this at all				Believe it strongly	

10. To what extent do you believe that the company's *competitive position* can be influenced through continuing education of its engineers?

    Explain:____

    If you *had* to summarize the strength of your belief very roughly on a scale from 1 to 5, how would you rate it?

1	2	3	4	5	Prefer not to rate____
Do not believe				Believe it	

11. To what extent do you believe the company's *capacity to innovate* can be influenced through continuing education of its engineers?

    Explain:____

    If you *had* to summarize the strength of your belief very roughly on a scale from 1 to 5, how would you rate it?

1	2	3	4	5	Prefer not to rate____
Do not believe this at all				Believe it strongly	

E. Career Paths

Career paths of engineers vary a great deal from one company to another and within companies, of course. The company's role in structuring career paths in each varies, too. The Panel is interested in understanding your views about both career paths and the company's role in that path.

12. Is it sensible to characterize "typical career paths for engineers" in the company? If so, how would you characterize the typical paths? If not, why not?

Explain:____

13a. What role does the company now play in managing career paths of its engineers? For example, is this left primarily to the individual or does the company take an active role?

Explain:____

13b. Do you envision any change in this role, in view of your own judgments about change in the industry more generally?

Explain:____

14. What is your view about the incentives for company engineers to continue their education? For example, do you place a high value on incentives created by the company? Are other sources of incentives valuable?

Explain:____

15. Are there in your judgment other important issues bearing on company values and policy that we have not considered?

If so, what are those issues? Why are they important? How are they related to assuring technical health of the company and technical currency of engineers?

DOCUMENT 3: DEBRIEFING QUESTIONS FOR INTERVIEWS

1. How much time did the interview take?

2. Were any special difficulties encountered in setting up the interview and conducting it?

3. Can the background "Information for Interviewers" be made more helpful for interviewers? How?

4. Can any of the questions be improved? Which ones? How?

5. Should additional questions be posed to help understand values, attitudes, and policy of policymakers in this arena?

6. Should special features of the company be kept in mind in interpreting the responses?

Interviewer Name________________________________

Company Name_________________________________

Phone____

DOCUMENT 4: INFORMATION FOR POLICYMAKERS

Information about this effort will be provided to the policymaker you've identified as a respondent in two forms. First, a formal letter will be sent to the individual from the Panel. Second, a more informal, oral statement should be made by you to apprise the individual about the effort.

The letter from the NRC Panel should help to assure the individual of the import of the work, and will at times facilitate the task of setting up an interview.

The letter below is a draft of the one that will be sent out by NRC.

(NRC Letterhead)

Dear____________________,

The National Research Council has undertaken a major research project for the National Academy of Sciences on the "Education and Utilization of the Engineer. " The work was initiated partly because of private and public sector concerns about the future vitality and competitiveness of high technology industry in the United States.

The main objective is to better understand how to assure that the United States industries continue to depend on able engineers trained in the right ways, at the right times, and with the right results. To achieve that understanding, NRC has been provided with financial resources to study this issue. The value will depend on the expertise of individuals representing major industries, universities, red government agencies at the local, state, and federal level.

The values and attitudes of top management are critically important to the NRC work. For this reason, the Panel on Continuing Education has undertaken a *pilot test* of a survey of corporate values and attitudes on the topic.

The pilot test involves an interview by one of your own managers. It asks for your judgments about technological issues and engineer training in the company. ______________ of your organization will receive an interview guide and will contact your office within the next few weeks to set up an appointment.

Your cooperation is essential if we are to build a better understanding of how to produce and innovate well in a rapidly changing technological environment.

Sincerely,
Panel Chairman

DOCUMENT 5: THE PILOT SURVEY OF CEO VALUES—QUESTIONS AND ANSWERS

Q. What is the "Pilot Survey of Policymaker Values"?

A. The Pilot Survey is a small field test of an interview protocol. The protocol is designed to determine whether and how well we can obtain information about top management views of continuing education for engineers.

If the pilot test of the protocol suggests that we can in fact obtain useful information about values and attitudes of top management, then a larger formal interview survey will be mounted.

Q. Why would anyone want to interview top management about their views?

A. No formal survey of CEO values and attitudes toward continuing education has ever been done. We know little, apart from anecdote and some personal experience, about how top management views the topic. Yet, CEOs' values seem important to our understanding of continuing education, its resources, and its future.

Q. Under whose auspices is this test being undertaken?

A. The test is being undertaken as part of a larger research project of the National Research Council's Committee on Engineering Education and Utilization. The Panel on Continuing Education of Engineers, a working group of the Committee, is responsible for the pilot test of the protocol and survey procedures.

Q. Who is supposed to be interviewed?

A. The Panel's primary interest here is in high-level general management values, rather than the values of human resources executives.

As a consequence, the target for interview is the CEO or EVP level.

Q. Who will do the survey?

A. The interview of a company CEO or policymaker will be conducted by a company manager or executive.

We believe this is a more efficient and practical approach than designating an outside individual or institution to conduct interviews. That is, an outside group would have less access to CEOs, be less expert in company affairs, and be a less informed and less able vehicle for questions.

Q. If the survey is done by insiders, will "objectivity" be an issue?

A. The panel believes that insiders can elicit information and fairly represent the CEO's response. But the Panel also recognizes that here, as in any other interview setting, coloring questions or taking license with responses is possible. And so we ask the interviewers to abide by the instructions in a reasonably conscientious way.

The more important factor here is insider access to the CEO or related executive level. It is *not* clear that an outside contractor can (a) get the access needed, or (b) pose the questions as expertly as an insider can. In making this judgment for the pilot test, the Panel does not forego other options for a larger survey. This depends in part on the experience of interviewers.

Q. What incentives are there for the policymaker or CEO to cooperate?

A. The incentives here are tied to the Committee and Panel mission.

If the CEO believes that understanding how to get the right people trained at the right times in the right way on the right things is important, then he or she will be more likely to cooperate.

If the interview procedure is sensible, in the CEO's view, cooperation is more likely.

Still, this may not be sufficient. If other incentives or approaches are likely to be more useful, in the interviewers' judgment, the Panel welcomes suggestions.

Q. What will the product of the pilot test be?

A. If the information produced in the pilot test is a reasonable characterization of top management views and helps to understand values about when, how, and why continuing education may be important, then a formal survey with a large sample will be considered by the Panel.

Q. Will results of the pilot test be made available to interviewers or to executive level policymakers?

A. A brief report on the pilot test and results will be made available. For information beyond the report, interviewers or respondents may contact members of the Panel on Continuing Education or the NRC staffer for the Panel, Vernon Miles.

Q. Who are the members of the Panel on Continuing Education for Engineers? Who is the principal NRC staff member posted to the Panel?

Panel Members

Dr. Morris A. Steinberg (Chairman), Vice President, Science, Lockheed Corporation

Mr. Ralph T. Dasher, Manager, Corporate Training and Education, Texas Instruments

Mr. Rod Hanks, Director, College Relations and Technical Development, Lockheed Corporation

Dr. Robert A. Hofstader, Manager, Education and Development Unit, Exxon Resources and Engineering Company

Professor Harold Kaufman, Polytechnic Institute of New York

Dr. Russell O'Neill, University of California at Los Angeles

Mr. Bernard Sallot, Advanced Technologies Group Services

Staff Officer

Mr. Vernon Miles, National Research Council

Consultant

Dr. Robert F. Boruch, Northwestern University

Appendix B

1984 Continuing Education Programs of Technical Societies

The information below summarizes the continuing education offerings of the technical societies during 1984.

	Type of Course	
Participating Societies	*Short and In-Plant*	*Audio, Film, Videotape, etc.*
Air Pollution Control Association (APCA)	x	
American Association for Artificial Intelligence (AAAI)	x	
American Chemical Society (ACS)	x	x
American Institute for Aeronautics and Astronautics (AIAA)		
American Institute of Chemical Engineers (AIChE)	x	x
American Society for Metals (ASM)	x	x
American Society of Civil Engineers (ASCE)	x	x
American Society of Lubrication Engineers (ASLE)		
American Society of Mechanical Engineers (ASME)		
American Society for Quality Control, Inc. (ASQC)		
Institute of Electrical and Electronics Engineers, Inc. (IEEE)		
Instrument Society of America (ISA)	x	x
National Association of Corrosion Engineers (NACE)		
National Society of Professional Engineers (NSPE)	x	
Plastics Institute of America, Inc. (SAE)	x	x
Society of Automotive Engineers, Inc. (SAE)	x	
Society of Manufacturing Engineers (SME)	x	x
Society of Petroleum Engineers of AIME (SPE-A)	x	x
Society of Plastics Engineers, Inc. (SPE)		

Appendix C

Professional Society Survey

Although several professional groups have conducted studies of society-sponsored continuing education for engineers, these efforts for the most part have been few and limited in scope. At a meeting in January 1984, representatives from nine such groups met and decided to update the available data (insofar as possible), using a simply formatted questionnaire that was sent to 40 organizations. Eleven responses were received, which have been totaled and appear below in the spaces provided in the questionnaire. (See Chapter 5 for a more detailed discussion of the rationale for and results of the survey.)

I Please list your current programs:

Program	*Average Number*	*Average Duration (hrs)*	*Average Cost ($)*
Conferences	2	3.1	135
Clinics	1.67	1	175
Seminars	15.27	2.3	406
Trade Shows	1	3	127
Home Study Courses	7.9	36 months (maximum)	69
Industry In-House Courses	3.55	3.25	6,425/pkg.
Video Program	.91	6.5	2,750 avg.
Audio-assisted Courses	.73	12	140
Modular Courses			
Case Histories	1.09		
Other Types:			
(Please list)			

II How do you supply or generate the technical subject content?

Source	*Response*	*Percentage*
Standing Committee	9	81
Ad Hoc Committee	6	55
Industry Input	5	45
Research Results	4	36
Government Report	1	9
Other	3	27

III How do you evaluate the effectiveness of the program on its relevance to members current/long-range needs?

Method	*Response*	*Percentage*
Attendance (or Participation)	9	82
Peers	4	36
Committee	5	45
Questionnaire	8	73
Other	1	9

IV What is the lead time to develop technical content and produce the program, course, or item?

	Response	*Percentage*
Almost immediate		
3 Months		
6 Months	7	63.6
1 Year	4	36.4
Other		

V Are your programs financially self-supporting?

	Response	*Percentage*
Individually	3	27
Collectively (some win, some lose)	7	64
Subsidize some	1	10
Subsidize all		

Are they funded by outside groups Yes 2 No 9

VI Do you have sufficient seed money to develop new and narrative programs for members' future needs?

Yes 7 No 2 Don't Know 2

Is it substantial? Yes 2 No 6

VII How do you determine the education needs of members?

Survey	8	Industry request	2
Committee	10	Government request	1
Staff	9	Academic supplement	2
Other	1		

VIII What group in your organization determines member needs?

Education Committee	10	Office Group	0
Technical Committee	6	Board of Directors	4
Other	2	Staff	8

IX Do you have a large organized member technical committee structure to determine need and programs for subset disciplines?

Yes 9 No 2

X Is the technology in your discipline:

Advancing	6	Declining	0
Moving Rapidly	4	Slowly Beginning	0
Standing Still	1	Less Relevant	0

XI Do your present conventional program delivery systems answer the need for rapid exposure of new technology to a large number of your members in a short time?

Yes 7 No 4

XII Have you recently looked at your methods of information/technology transfer to your members and others?

Yes 10 No 1

Is it adequate to their needs?

Yes 8 No 2

XIII Do you think your delivery systems need to be modernized?

Yes 6 No 4

Have you considered, or are you considering:

	Yes	*Percentage*
Teleconferencing	7	64
Video courses	8	73
Satellite conferencing	3	27
Audio information tapes	5	45
Computer programmed learning courses	7	64
Personal computer instruction software	7	64

XIV Do you spend considerable personnel/financial resources working with other groups for continuing education?

	Yes	*Percentage*
Academia	4	36
Government	2	18
Industry	3	27
Other Societies	4	36

Do you feel the trend in programming for your members is toward multidiscipline or multisociety programming to adequately cover the subject for continuing education?

Yes	*Percentage*
3	27

XV Do you have member recognition, motivating, or credential listing programs?

	Yes	*Percentage*
Plaques, Certificates, etc.	9	82
Certification Programs	4	36
Central Credential Registry	5	45

Does your organization assist the member in planning a coordinated, long- or short-range personnel development program?

	Yes	*Percentage*
	5	45
Is it recognized by industry?	6	55
Academia?	5	45
Professions?	5	45
Do you think these programs are a factor in motivating your members to participate?	4	36
Do you plan to install a formal Professional Development/Continuing Education program in the near future?	2	18

	Yes	*Percentage*
XVI Do you have a profile of your membership?	11	100
Is it stored in your computer?	11	100
Can you manipulate the data for analytical purposes?	10	100

What is the median age of your members? 44

XVII Does your organization work with ABET (or other organizations) to accredit the content of your Engineering Curricula?

Yes 9 No 2

GENERAL COMMENTS:

This survey hits only the highlight questions. It is intended only to establish data for further study. The overall study is intended to point out areas for further in-depth analysis.

Please feel free to add your comments, constructive or otherwise, to the above questions, or on any other subject in continuing education that you feel is relevant or needs further amplification.