The Functions of Engineering Extension

E. LEIGH SECREST

College of Engineering, University of Oklahoma, Norman[1]

Ours is a time characterized by an almost overwhelmingly avalanche of technological and scientific advance, innovation, and application. The magnitude of this rate of change poses a tremendous challenge to the mature engineer. The purpose of this paper is to present a discussion of one aspect of this challenge—the continuing technical education of the engineer beyond the initial period of his formal or academic education. Traditionally, universities have sought to meet the need for continuing engineering education through programs of Engineering Extension. As used here, the term engineering extension is expanded to include all those phases of continuing technical education of importance to the practicing engineer.

The challenges of any profession or of any organization can be met only by the individuals of which it is constituted. Similarly, continuing education is a highly individual affair. In the broadest sense, an individual's entire life can be considered an education. Every technical experience of an engineer contributes to a greater or lesser degree to his technical education. The men most successful in the engineering profession are those who have learned to maximize the contributory nature of their experience, as well as that of their formal training, to their total education. It has long been recognized by educators that graduate education has to be tailored to the needs and interests of the individual. Continuing education becomes even more of an individual affair and must be recognized as such. There can be no simple, pat recipe for combatting obsolescence. Instead, we must search for patterns or methods of approach that will provide the proper opportunities for engineers with widely varying needs and professional skills.

If continuing education is an individual affair, it is pertinent to ask why either an industry or a university should concern itself with the problem. For that matter, why should the profession concern itself? Consider for a moment the position of industry in the matter. The success, or even survival, of an industrial activity depends upon the realization of a profit in the face of competition. To compete successfully and to maintain healthy growth, the industrial firm must be aware of the current needs of the country in areas closely related to its product line and experience. It must be keenly aware of all the methods by which these needs can be met, either at the present or in the future by means of reasonable development. Finally, it must exhibit inventiveness in matching the means to the end—in applying current science and technology to the needs of the economy. The industrial concern can discharge these functions only through the efforts of individuals. If the engineering staff of a firm is outdated in its methods and knowledge, product opportunities will inevitably be lost to a competitor who is up-to-date, or at least who is not so far behind. Creeping obsolescence of a staff is not easy to detect. The early signs may only be errors in timing—the development that takes a little longer than the competitor's—or the project that costs a little more than it should. This hazard is not a new one—it has always been with us—the professional man has always been required to read and study in order to keep abreast of his field. The only thing that is new is the rate at which new data is being generated and the general depth of formal technical skill required for even a partial mastery of the more sophisticated developments.

[1]Now with Texas Christian University, Fort Worth, Texas.

One accepted practice for bringing new skills into a mature engineering organization is through the hiring of new graduates. Hopefully the blend of their new ideas and the experience of the older staff should result in a strong team. This concept will work in practice, however, only if the members of the team speak at least some of the same language. As a matter of fact, opportunities for continuing education often loom large in the eyes of new graduates who are seeking employment. The firm which ignores the need for continuing technical education may find that the new talent which it needs so badly cannot be obtained.

Traditionally, the world's universities have risen to meet the challenge of the age—their primary function has always been, and continues to be, the education of the citizenry. Once education is understood as more than formal schooling or training, the interest and the obligation of our universities in continuing education becomes quite clear. The thing that is not clear is that of method and approach—we are still searching for better and more effective ways of serving this function.

Granted that both industry and universities have important obligations in this matter, what about the professional societies and the engineering profession as a whole? This can best be answered by quoting from a recent statement of Jesse Shera of Western Reserve University. Dr. Shera was speaking of another professional group that is also beleaguered and hard pressed by the rapid changes in technology and the resulting flood of data, the librarians:

> "The test of a profession, as well as those admitted to its rights, privileges, and rewards, is its ability to respond to challenge, to the need for change, and to the opportunities that the future holds."

Let us return to the main object of interest once again—the individual engineer. Why should he be interested in continuing education? The most direct answer is that, without it, he will soon find himself "on the shelf" technically. He will be able to handle only those tasks which his more up-to-date contemporaries do not wish to assume. When we call for the services of a physician, we always assume and wish to believe that he will bring the very latest of medical knowledge to bear on your problem. As a professional, the engineer has the same obligation to his employer or client, as the case may be.

Granted that some self-renewal or continuous education is necessary, it still is not obvious that a few hours of reading once a week or so will not suffice. To add a dimension of quantitative thought to our discussion, we must probe a little deeper into the specifics of engineering and take a closer look at some recent changes.

To understand the technical changes which have taken place in engineering education during the past two decades, one must do more than look at the course titles in curriculum listings. Even in those schools considered most progressive in engineering education, old familiar titles such as materials, thermodynamics, dynamics, etc. still recur. The content of the courses, however, may be quite different from that of 25 years ago. Consider some examples from each of four important areas of engineering:

1. Structures and Materials
2. Energy Sources
3. Information Handling
4. Environmental Interaction and Control.

Almost every engineering project can be analyzed in terms of these broad functional categories.

What has happened in structures and materials? First, we know that the flood of new materials with new properties is growing in volume. This in itself is not new. The new element is the *way* in which many of these improvements are being made—by applications of solid state physics and chemistry and by working with atomic properties of materials rather than their gross engineering properties. Structural design has been revolutionized by high speed computational methods. The modern structural designer can now systematically study whole families of design concepts in a fraction of the time it formerly required him to check one or two design points. This leads to better solutions and to a more creative approach to design.

What about energy sources? Within the past two decades new terms such as plasma ion propulsion, magnetohydrodynamic generators, nuclear reactors, and direct energy conversion have been added to our vocabulary of technology.

In information handling, we have seen miniaturization, micro-miniaturization, integral circuits, develop to the point of standard practice. We now see such things as molecular electronics, laser communications as standard practice of the near future.

In environmental control we hear such new terms as molecular flow regime, plasma drag, ablative cooling. Irreversible thermodynamics and non-equilibrium thermodynamics have become important.

All of these developments share three properties:

1. The atomic nature of their origin
2. The mathematical sophistication required for their treatment.
3. The methods required for their incorporation into engineering systems.

The first two of these properties are not unrelated. It has long been realized that satisfactory descriptions of atomic phenomena require sophisticated mathematics. As the microscopic properties of materials have become more significant to the practical metallurgist, the methods and steps required for the reduction of science and theory to engineering practice have grown similar to the experimental methods formerly reserved for science than to the "busting Lab" techniques of early engineering.

These outward symptoms of changes caused many educators and industrial managers to leap to some wrong conclusions a few years ago. They made the easy assumption that, since the tools needed by a modern engineer are so similar to those needed by a scientist, his formal training should be the same! Therefore, some engineering curricula became indistinguishable from science curricula, and many firms hired physicists and chemists to do engineering instead of science. The results were disappointing in both cases. During the past few years the trend has been reversed somewhat, and most engineering educators now agree that certain attitudes and ways of thinking are as important to an engineer as are the formal technical skills we place in his hands.

Nevertheless, we are led to the inevitable concensus that the modern engineer needs more sophisticated tools at his disposal than ever before. Twenty-five years ago engineers more often than not did not reach the point of ordinary differential equations in their formal undergraduate training. Today's undergraduates have been introduced *to partial differential* equations by their third year! Students learn to program their problems for digital computers at least by the end of their sophomore year!

These observations are relevant to the question, "Why can't a practicing engineer simply read and keep up?" We have at hand at this point a partial answer to that question—if the engineer relies on an outdated formal education, he does not have all the basic tools required for mastering new technological developments. Acquisition of these tools by individual reading is possible but not highly probable for a busy professional man.

If one considers merely the task of keeping abreast of the detailed literature in a field, he is immediately impressed by the enormity of the task. Someone has estimated that, if a chemical engineer set out to read 8 hours a day all the literature of conceivable importance to his field, he would fall behind 3 years for every 1 year he read! This leads to a comment recently made by John R. Pierce (Pierce, 1964):

> ". . . I am sure, without counting or calculation, that a person who received all documents mentioning transistors, or even all documents mentioning some aspect of the transistor, would be smothered under the flood of information and misinformation it would produce. What the person who consults the library needs is not everything about a subject, but the best information about a subject."

Dr. Pierce was referring to some of the grandiose schemes that have been suggested for relieving the information retrieval problem by some magical computer system, but his remarks cast some light on the dilemma of the man who seeks self-renewal on a "do-it-yourself" basis.

The above arguments demonstrate two points:

1. Technical obsolescence is a real threat to the practical engineer.
2. The individual must have assistance by his profession, his employer, and the universities in order to continue his education after he completes his first round of formal training.

It is pertinent to discuss some of the possible approaches and patterns which could be used for such a program. At least one industrial executive has estimated that the knowledge which an engineer receives during his formal training will give him a technical half-life of about ten years. One possible approach to continuing education would, therefore, be for the individual to return to the campus once every ten years for a new degree. From the point of view of the man's employer, or his clients, this is a less than satisfactory proposal. It is difficult to release a man who is in a position of responsibility for a sufficiently long period to complete a degree program. Such an approach is undesirable also from another point of view. The mature engineer with ten years of experience does not need the same kind of degree program as does the young man who is fresh from undergraduate study. To attempt to stuff the mature engineer into the same mold would be a waste of both his time and that of the faculty. It is important to distinguish between at least two types of continuing education. The ASEE has referred to these two types of continuing education as "up-grading" and "up-dating". (Walker, 1962) In the case of the former, the objective of the continuing program is the broadening of the man's knowledge into other fields or a deepening of his specialized knowledge of a particular field. For example, a man who receives an undergraduate degree in mechanical engineering and accepts employment with industry may, after a few years, feel a need for returning to the campus in order to obtain a higher degree in his specialization. Such work would be an "up-grading" function. Or it might be that a practicing engineer whose responsibilities had been broadened by his employer to include management and administrative functions would wish to return to the campus to obtain a second degree or an advanced degree in another field. This would also be an "up-grading" function.

On the other hand, consider the engineer who receives a doctor's degree and then enters practice either as an independent engineer or an employee of industry. After a certain number of years, say ten to fifteen, he will find that many of his skills have become rusty and that he is having difficulty in following some of the newer developments in technology. In this case he would desire additional formal education in order to "up-date" his inventory of skills.

In the case of a program designed for "up-grading" an engineer, it is probably desirable that he work under a formal degree program toward an additional degree. In the case of "up-dating", an additional degree is probably not required—in this case it is the information and skill acquisition which is the primary objective for the individual. In either case, the engineer's employer will hesitate to accept a full-time loss of his services for extended periods of time. Such an absence from his professional work would also very probably work to the detriment of the man's career, in spite of any reassurances which he might receive to the contrary. Therefore, one of the challenges which we face in programs of continuing education is the development of mechanisms which will allow either or both of these two types of continuing programs to be achieved without extended periods of full-time loss to the profession. This should be one of the primary functions of engineering extension insofar as our modern industries are concerned.

If one considers the different approaches which have been used over this country in attempting to meet this challenge, he is immediately impressed with the wide variety of methods which have been tried and which have worked with varying degrees of success. This, of course, has always been an outstanding feature of our system of higher education. We have always been free to develop the optimum method of achieving our goals on an individual and localized basis. Charles H. Norris, Chairman of the Department of Civil Engineering, at the University of Washington gave a very good summary of this point (Norris, 1964):

> "Continuing education programs and activities are carried on by many engineering colleges today, and particularly by those located in or close to urban centers. Some of them are degree oriented; some are not. Some of them operate continuously throughout the academic year, usually in the evenings; some involve short courses or conferences scheduled at appropriate times throughout the year. Some are one or two week short courses or conferences offered in summer school. Some are on-campus programs; some are off-campus, either at their branch campus or at the location of a large group of interested engineers. A notable feature about all of these efforts to provide continuing education for professional engineers is the tremendous variety that exists. In certain respects, this is good—in fact, necessary. Each school has a certain unique capacity, objective, and clientele."

One of the tasks which faces those interested in engineering education here in Oklahoma is the systematic development of an approach to the problem which will work for this locale, for our talents, and which will satisfy our needs.

In working with this problem and in attempting to find practical solutions for this region there are several key elements, or features which must be contained in any satisfactory solution. These are:

1) The program must take cognizance of the fact that the professional engineer pursuing a program of continuing education is basically a different kind of student from that for which our resident programs are traditionally designed.

2) The educational program in many instances must go to the student. It is not practical to expect a professional engineer to interrupt his career for extended periods of time for "up-dating".

3) The program must allow for a wide range of individual differences and interests in the students, their employers, and the universities involved.

4) The program must be of such a caliber as to compete satisfactorily in quality on a national scale.

5) The program must provide both for the up-grading and for the up-dating functions for practicing engineers.

It will not be an easy task to find a satisfactory solution with all of these characteristics, nor will it be an inexpensive solution. In many cases it will involve changing administrative procedures. The problem for the State of Oklahoma is further complicated by the fact that our technical resources are still relatively scarce. Whatever the solution adopted for our region may be, it must not further dilute the effective concentration of these resources on the state's problems. Rather we must search for mechanisms by means of which an up-grading and up-dating program for our professional engineers can strengthen and speed the industrial growth of the state.

BIBLIOGRAPHY

Norris, Charles H. 1964. Continuing Education—A Continuing Problem. The Trend in Engineering, College of Engr., University of Washington, Jan., 1964: 4-6.

Pierce, John R. 1964. Men with Ideas. Intl. Science and Technology. July, 1964: 101.

Walker, Eric A. 1962. Goals of Engineering Education. *Jrnl. Engr. Ed.*, V. 53, No. 4, Dec. 1962: 209-211.