
The Role of Engineering Extension as a Service to Industry

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INTRODUCTION

For the purpose of this discussion Engineering Extension shall be defined as the comprehensive instructional service on engineering subjects which includes credit and non-credit courses at the undergraduate and graduate technical or professional level held off the campus, and a program of short courses, conference, and institutes held on or off the campus. Specifically Extension brings educational benefits to students other than those regularly enrolled on the campus.

Traditionally Engineering Extension has been involved primarily with after-work courses usually at the graduate level. Although the subjects are generally taught by instructional staff who drive to distant cities, they may also include courses taught on campus once a week for employed engineers who come to the college.

The usual clientele for such programs are B.S. degree people interested in getting an M.S. degree. The average student will begin the program within three years after leaving college, though some may delay beginning for 10 years or longer. Generally he takes one three-hour course at a time, in which case he will require 10 semesters or 5 years to get the M.S. degree.

However, other students in extension courses are primarily interested in what they can learn that will be of help to them in their present working assignment. These people are usually not interested in advanced degrees; in fact many such are Ph.D's taking specific courses to round out their background.

The problems relating to these broad areas of extension have been discussed many times and I am sure are generally familiar to you. I would like to talk with you primarily about the new type of problem commonly referred to as "Technical Obsolescence" and the way in which Engineering Extension can be of help to industry in improving the technical competence of its employees.

First, we might look at the general background of the problem: What it is, what caused it, and whether it will get better or worse. Second, we will consider the present status of programs for continuing education of the engineers in industry. Third, we will evaluate the major problems that now exist. Fourth, I will give my views on what is needed most at this time.

I. *BACKGROUND*

The background material and figures to follow were presented by me[1] at the 129th Annual Meeting of the American Association for the Advancement of Science, Philadelphia, Pennsylvania, December 27, 1962.

Dr. Thomas Stelson[2], Head of the Civil Engineering Department at Carnegie Institute of Technology, is usually credited with first drawing attention to continuing education needs by his intriguing article "Education for Oblivion", which appeared in the Carnegie Alumnus in April 1961. His suggestion of the necessity for the graduate to systematically spend 10% of his available time in keeping up with new developments in his field and an additional 10% in continuously refreshing himself on those parts of his training not currently in use was widely quoted, and shocked the scientific world into a realization of the magnitude of the problem. However, prior to this, two little-known and seldom-quoted articles had appeared. The late Mr. E. V. Murphree[3], then president of Esso Research and Engineering Company, spoke on "How Can The Scientist Keep Up With Science" before the American Chemical Society in 1960, and Dr. Arthur F. Scott[4], Head of the Chemistry Department at Reed College published in the Journal of Education in 1960 an article entitled "Retreading the Chemistry Teacher". Since 1961 there has been a steadily increasing interest in this area of education and virtually every professional society meeting in the last two years has had at least one paper on the subject.

a. *The Supply and Demand Picture*

First, let us look at the growth trends of industrial research and development and the availability of manpower, as related to the problem of continuing education needs. In Figure 1* is shown the growth of industrial research in terms of total expenditures and also as a percent of the Gross National Product. You will note that the expenditures have increased from $1.6 billion in 1947 to about $10½ billion in 1960 and are estimated to increase to 18 billion by 1970. Since 1952 the rate of growth has been more rapid than that of our Gross National Product. It is beginning to level off and will probably settle at about 2.4% of the GNP, according to the analysis by Dr. Yale Brozen[5] of the University of Chicago.

The early 50's, thus, was the period of maximum utilization of basic science by industrial research. Many new people were hired from colleges each year, and due to the continuous expansion, there were ample opportunities for the comparatively few older employees. However, the recession of the late 50's and the sheer cost of industrial research shifted the emphasis from increasing size of staff to raising its efficiency, and inevitably, more attention was paid to the productivity of the individual man. It became apparent that research net profits were more a function of the output of a comparatively few individuals than the total number of people on the staff.

In its search for the creative, productive individual, industrial research began concentrating on the outstanding man, exemplified by the bright young PhD. The effect of demand on the output of doctoral candidates is shown next. Figure 2 shows[6] a steady but not spectacular rise in physical science, and Figure 3 shows[7] a more marked increase in chemistry and engineering. Figure 4 shows[8] that the percentage of B.S. degree engineering and science candidates from which our future doctoral people will be drawn is shown is about constant, with math increases almost balancing the reduction in engineering.

In Figure 5 are shown[9] enrollment trends in engineering, both undergraduate and graduate. On the same scale is plotted the rate of expenditure of funds for research and development. This figure shows that advanced degree enrollment was slow in responding to increased demands from research and development, but since 1956 both have risen at about the same rate. However, it is obvious that graduate enrollment cannot continue to increase in the face of decreasing undergraduate enrollment without some deterioration of quality of M.S. and doctoral candidates. The unbalance of supply and demand, as given[10] in an August 1962 report "Demand for Engineers" by the Engineering Manpower Commission of the Engineers Joint Council, is shown in Figures 6 and 7. Engineers Joint Council reported last summer that in 1963 employers fell short of fulfilling their requirements for new graduates by 15 to 20% but still retained the same goals for 1964. This same report shows that the hiring of experienced engineers dropped 11% in 1963 and the recruiting goals for 1964 had decreased another 11%. Employers reported that they successfully filled their recruitment goals for experienced engineers.

b. *Age Distribution of Engineers and Scientists in Industry*

Of interest also is the age distribution of technical people in industry. Figure 8 shows[11] for research and development the percentage of workers at each age, and the year of first degree, assuming that it was obtained at age 22. Note the break in the curve at age 35. Figure 9 shows[12] also[13] the data on all engineers in industry and all scientists. In Figure 10 is shown the cumulative total percent of engineers in research and development and all industry, and all scientists for each age and year of first degree. From this you will note that 80% of all engineers are below age 44 and 50% are between age 28 and 44. Another way of saying this is that about half of the estimated 700,000 engineers in industry were educated between 1938 and 1954, the latter date being about the time that major changes began to be made in the college curricula. This is the group considered

*The '47-'57 data from the Res. and Dev. Board, Dept. Defense, April 10, 1953 (Mimeo.); '53-'60 data on industrial research performance from "Reviews of Data on Research and Development", NSF 61-51, Sept., 1961; '53-'59 data on Gross National product from "Reviews of Data on Research and Development", NSF 61-9, Feb., 1961.

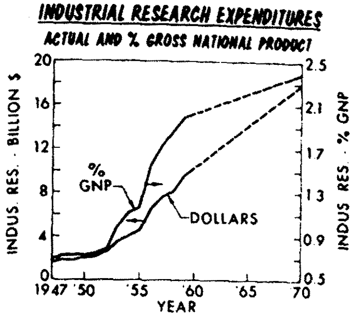
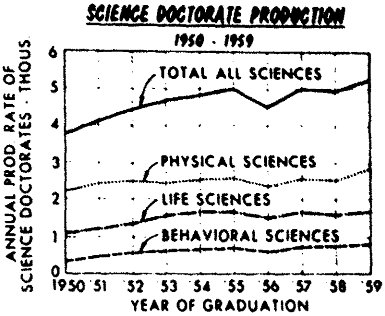


FIG. 1



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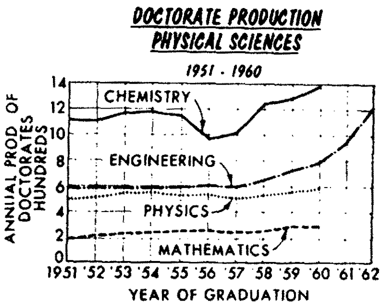

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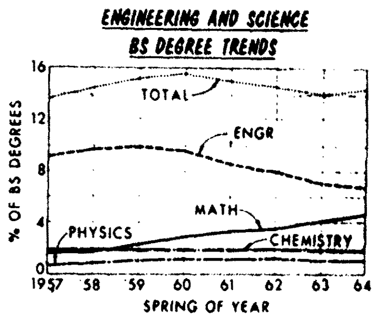

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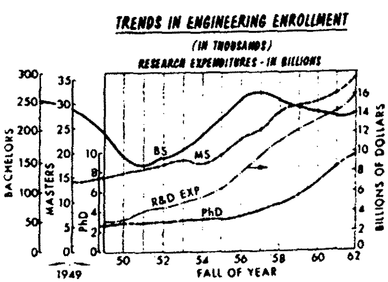

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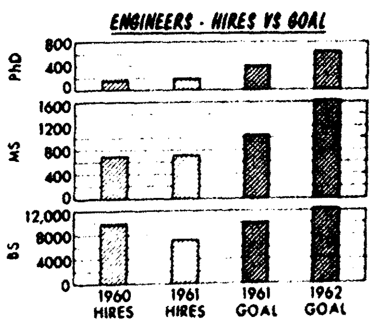

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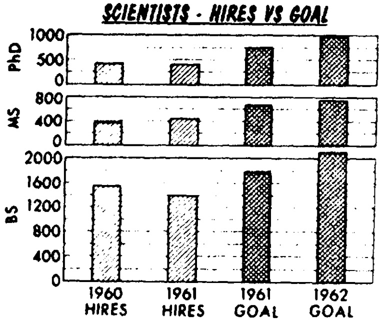

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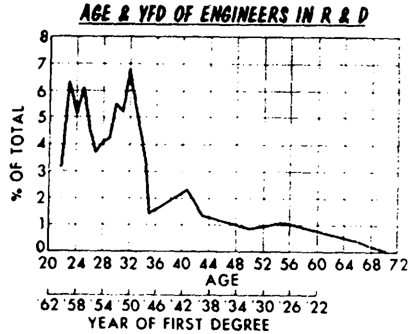

FIG. 8

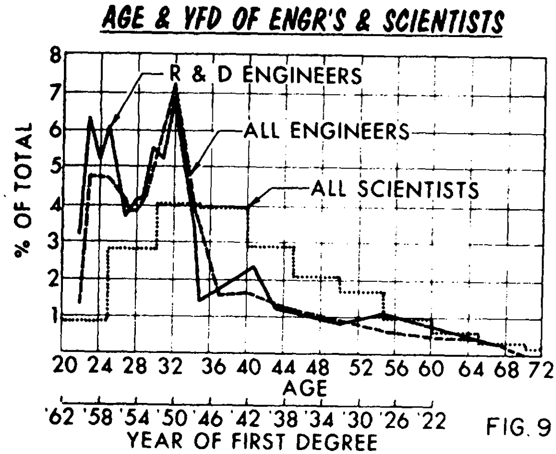

FIG. 9

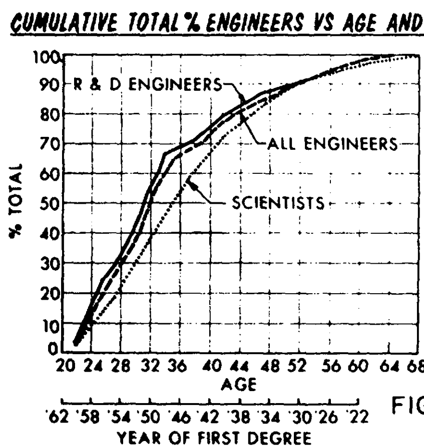

FIG. 10

to most in need of re-education and number-wise is more than the total undergraduate engineering enrollment. To this we can add also a sizeable number from the approximately 900,000 scientists in industry and education. This will give you some idea as to the numbers which will be involved in the re-education program.

From the data presented on trends we can draw the following conclusions: (1) established industrial research organizations will probably continue a steady but modest growth as our Gross National Product increases, and this growth, combined with the needs of governmental research plus new research organizations, will keep demand for advanced degree people high. (2) the expected continued growth of industry other than research will keep demand for B.S. degree candidates up. (3) response to demand has been slight and there is little likelihood that supply will increase sufficiently to meet the requirements for both B.S. and advanced degree people in the next decade even with the increasing number of college students expected beginning this year. (4) to meet our nation's total technological needs we must increase the productivity of the large number of scientists and engineers hired since pre World War II, a retraining program that will get larger and more difficult each year as a percentage of older people increases.

c. *Growth Rate of Knowledge*

I am sure the growth rate of knowledge is well known to you. The latest estimate by Gaylord[14] is that between 1960 and 1967 our entire store house of scientific knowledge again will have doubled. In the nonscientific fields, the total body of knowledge is still estimated to double only about every 30 to 50 years. The scientific papers published[15] throughout the world every day would fill seven complete sets of Encyclopedia Britannica, or would total 60 million pages annually. The working engineer has been literally swamped by the quantity and complexity of the current technical literature.

d. *Changes in College Training and Resulting Communication Problem*

I am sure you are also familiar with the changes in curricula since about 1954 when most universities began teaching the use of computing machines and also emphasizing the "Know Why" at the expense of the "Know How" approach. The inter-disciplinary aspect of collegiate training and the incorporation into the educational system of new research developments made since World War II have resulted in a new generation of graduates, not only differently trained, but who seem to speak a new language. This has resulted in a communication problem between working engineers and recent graduates with the result that the older employee find it increasingly difficult to update themselves by learning from the new people.

e. *Industrial Pressures and their Effect on Motivation*

Industry must accept a part of the blame for the present situation, because it has geared its reward system to the ability of the individual to apply basic knowledge to its particular problems, and accordingly has not motivated its people to spend time and energy maintaining technical competence at the expense of handling the problems of the day. It has encouraged specialization, without providing adequately for re-education of the man whose specialty field became obsolete.

Ironically the problem of obsolescence is likely to be largest for the best engineers those who have not stuck to narrow speciality over the years, but who have risen into management and have the responsibility for a diverse engineering group or development laboratory. Here the problem is largely one of communicating with the young men in the organization and reaching decisions on suggested approaches involving terms and fields such as feed-back control, computer, nuclear engineering and inertial guidance, rocket propulsion, plasma physics, solid state electronics and so forth, all largely unknown when the 45 year old manager was in school.

g. *Social, Recreational and Civic Responsibilities*

Lastly, continuing education has in the past simply not been an accepted way of life. The emphasis of the employed engineer has been on participation in civic, social and recreational affairs rather than continued self-study. Only recently have both the engineer and his company come to realize the situation into which both have drifted and the stake both have in correcting the situation, as well as preventing its occurance among the younger people on the staff.

II. *PRESENT STATUS*

a. *In Industry*

There is a growing concern in industry about the educational needs of its engineers and scientists. It has been estimated that about $50 million is currently being spent on all phases of continuing education. The magnitude might be a cause for complacency, but there is a genuine concern about the quality of extension courses for credit taught on an overtime basis by professors to students after hours. Also the increase in members of students staying in school for graduate work has reduced greatly industry's needs for M.S. degree extension programs. The rising interest in industry is for carefully planned and well taught courses designed to bring the engineer 10 years or more out of school up-to-date with courses as they are currently being taught.

The Bell System has been one of the leaders in developing with selected universities, programs specifically designed to up-date their people. Western Electric, for example, has provided for 7000 of its employees to take 1000 courses since the program began in 1958. Twenty universities have cooperated in providing the instruction. The 1964-65 bulletin of graduate engineering training programs in Western Electric looks like a typical university catalogue.

Another Bell affiliate, American Telephone and Telegraph, has worked out an arrangement with Rensselaer Polytechnic Institute whereby two selected groups of engineers come to Troy for alternate 3 or 4 week periods for refresher courses in engineering mathematics, engineering economics, electron physics, modern electronics, modulation theory, digital system theory and switching systems. These classes meet 4 hours a day, Monday through Friday and 3 hours on Saturday, with each group spending a total 441 hours in class. The subject matter to be covered was worked out jointly between AT&T and RPI. Northern Natural Gas Company has developed a program with the aid of Floyd W. Preston of the University of Kansas and currently is sending selected people to that school for refresher training. Jersey Production Research Company in Tulsa has recently completed a $100,000 classroom wing in which courses are scheduled[16] almost continuously. An average of 3.3% of the total professional manpower is spent in class with instructors drawn from its own staff and from universities. Esso Research and Engineering Company has offered 37 two week courses in its graduate technical education program during the past 4 years. The Humble Oil and Refining Company[17] at Baytown has now offered more than 100 such courses. Both companies draw on university personnel for the bulk of their teaching. Other companies with very active continuing education programs in their own plants are IBM, General Electric, and Westinghouse. It is interesting to note that IBM[18] in 1955 adopted the policy that continued education is part of a man's normal daily working assignment. The bulk of American industry is beginning to comprehend the wisdom of such a policy.

b. *In Universities*

Each year the April issue of the Journal of Engineering Education lists the University short courses planned for the following summer and fall. MIT and Michigan have been the leaders in such offerings with MIT currently having about 1700 students per year. These programs are costly with MIT currently charging $200 per week as registration fee. They offer the operating engineer retraining in a narrow, highly specialized field. For a complete refresher course a man would have to attend a large number of courses and spend a considerable amount of money.

There is a growing interest in UCLA's "Modern Engineering For Management". This is known as the five week scientific cram course in the fundamentals of science and technology. The aim is to make the manager conversant with the concepts important in modern engineering. While he does not become an expert in any particular field he gains at least enough insight to comprehend and evaluate research and development work he may be called upon to direct. The cost is high: $1500 for tuition plus $20.00 per day for room and board. General Electric was so impressed with the course that it paid UCLA $50,000 to repeat the course for an all G.E. class and has now taken over subsequent sessions, calling on university people from the country to provide the instruction. Its estimated costs including the salaries of the students who attend are $6,000 per student for the 5 week course and it will spend roughly $350,000 a year on the program.

The University of Texas produced a 3-week course last summer charging a tuition of $1200 for instruction, supplies, room and board. Brooklyn Polytechnic Institute also conducted a short course for business leaders last fall.

I am sure many of you read that MIT received five million dollars last year from the Sloan Foundation to conduct a program of retraining working engineers. The program was started in September 1964, with 20 carefully selected men in their 30's and 40's who will spend a one year period on campus in a program of individually tailored study and guidance. Dr. Mickley, Director of the Center admits that the MIT staff expects to learn as much from its students as it teaches them. Tuition is $3600 per year, and the school expects to seek additional outside funds to break even. Although the number in the program will increase somewhat, it is unlikely that more than 120 people can be accommodated per year.

There is at present no university offering a broad program of updating the working engineer at a cost he may absorb himself or at which his company may be interested in sending him.

c. *Professional Societies*

Historically the meeting of the professional society has been to provide a forum for the presentation of results of new investigations. There is a communication gap which is making increasingly difficult for the engineer to develop current operating technology from research presentations and papers. The professional societies are attempting to bridge the gap through education of the authors in manner of presentation, through raising the level of technical competence of the listeners, and through joining research and technology by state of the art monographs, the preparation of which is subsidized by the society. There is also consideration being given to modification of the current pattern of meetings by providing for more general review papers and special teaching symposia to be conducted prior to or during the meeting. In other words the emphasis by the society is on providing a more efficient teaching mechanism than paper presentation and it expects to utilize the services of university professors inceasingly in its meetings. Some societies are considering establishing a special level membership attainable only by a rigid and lengthy program of study that is outlined by the society. This is expected to involve some university courses.

d. *ECPD Committee*

The most extensive study of continuing education needs for engineers of the nation was started in summer of 1964 under the sponsorship of ECPD. A Council on Continuing Education was formed with representatives of ECPD, the National Society for Professional Engineers, and the American Society for Engineering Education. The ECPD sub-committee will study the problem as it relates to the professional society, the NSPE the industry problem, and ASEE the role of the University. The sub-committees are actively working now and expect to complete the first phase early in 1965. It appears likely that this continuing education study will be merged with the goals of engineering study currently underway and that we may expect a suggested program for not ony the education of our engineers but for keeping them continuously up-dated.

III. *PROBLEMS THAT NOW EXIST*

a. *Uncertainty as to what is needed*

At present there is considerable uncertainty as to what the working engineer needs. In interview and response to questionnaire he indicates that he wants to be brought up to date with current technology. However, this would result in his soon becoming out of date again. Most educators believe that he needs to be brought to a threshold level of confidence which will encourage him to read the current literature and develop his own program of continued self-education. The estimates of the length of time necessary to bring him to this threshold vary from a week to one year.

b. *Lack of Motivation*

Although there is a general concern by engineers in industry, among many there is still lacking a strong motivation for making the financial and time commitment necessary for a major re-development program. This is due largely to the fact that engineers have become accustomed to relying on their companies for such training as is necessary. The only strong motivation is among those individuals who have either changed jobs recently or face the prospect in the near future. Under the present system little motivation is being provided by either of the company or the professional society.

c. *Financing*

The re-education programs are costly and the financial responsibility of industry, the individual and the state or federal government has not been established. The attitude of industry is usually that it will share in the cost of programs taken by the individual on his own time which relate to his own broad development in fundamental areas. If the training is related to the employee's immediate assignment or that contemplated in the near future, instruction is usually provided during the working day and all costs are paid by the company. However, the company expects the individual to maintain a basic level of competence such that he can absorb readily the applied traning which it provides.

So far the state and federal government has not assumed financial responsibility for providing refresher training for employed engineers.

d. *Organization of Specific Classes*

The major problem at present is the organization of large enough classes in view of the varying backgrounds and interest of employed engineers and their geographic distribution. In the Tulsa area North

American Aviation and the American Airlines are engaged in a far-reaching studies of the complete educational needs of all their engineers. If this is done widely in industry and a mechanism set up for collecting such information and making it available to universities, the development of specific programs would be greatly facilitated.

e. *Problems in Teaching*

One should not minimize a difficulty of teaching working engineers. Their motivations are greatly different from regular first time students. They are not interested in grades, but rather in how they can utilize information. They are very time conscious and want efficient presentations. Not every brilliant lecturer can effectively teach a large body of knowledge to a group of mature experienced engineers in a comparatively short time. The students particularly object to those teachers who display their own vituosity by working out complex problems on the blackboard at breakneck speed. Since the material to be presented often cuts across the departmental lines the selection of the staff and preparation of the lectures is not an easy one. The course director at UCLA estimates that 20 hours of preparation may be necessary for one hour of class lecture. Industry generally wants the best possible teacher, even at a considerable higher rate per instructional hour.

IV. *WHAT IS MOST NEEDED*

The over-all situation might be described as being in a state of ferment. There is a great need for leadership. Since this is essentially an educational problem the university through its extension service should take the lead by identifying the material to be taught and offering the courses. Industry and the state government should provide the risk capital. The National Science Foundation and the U.S. Department of Education have both expressed interest in providing funds for research on methods of importing knowledge to engineers out of school for a number of years. Both however, feel that actual courses should not be financed by federal funds.

An inventory of needs would be most helpful in the planning. Industry can secure this, but requires guidance from the universities since it must relate its needs to what is available. Professional societies can also be of help by identifying the re-education needs in particular disciplines and by endorsing and publizing courses offered by universities.

It is likely that Engineering Extension will be called on increasingly for the teaching of special courses designed to up-grade the people in single companies. Although the needs may differ somewhat from one company to another, it is likely that there will be sufficient common ground to allow the pooling of needs in education. In other words, courses developed primarily for one company may well be opened to others, thereby keeping the unit cost of instruction to a minimum. The advantage here is that the company desiring to send only one or two people may participate in someone else's program.

Thus, we have shown that we are entering a period of greatly increased requirements in the area of adult education, primarily in the part relating to the up-dating of scientific and technical personnel. The role of engineering extension will be to assist in identifying the needs of companies and individuals and in developing with the instructional staff of the school a specific program designed to increase the technical competence of the working engineer.

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