

NEW DIRECTIONS FOR ENGINEERING*

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The engineering profession remains vital because of the continual re-examination and criticism of its own goals and practices. Engineering education is traditionally in a state of flux. The current stimulants to re-examination and change are (1) public problems and scandals such as air pollution, population growth and mass transportation in which the engineer is involved as both culprit and savior; (2) high speed computation which is revolutionizing every aspect of engineering practice; (3) the rapid production of technical information which is forcing the practicing engineer to spend a considerable effort on re-education; (4) the diversion of much of engineering education and research away from application and toward science and (5) the development of new opportunities such as bioengineering and medical-engineering.

The recent ASEE study has not provided a sufficient set of goals or an acceptable set of recommendations for the future development of engineering education. Hence further efforts on the part of the engineering community are necessary to establish new goals and directions.

These goals should include better communication with the public, recognition of the social consequences of engineering projects, enhancement of engineering as a pro-

fessional career, development of stronger support of the engineering profession by industry and the government, increased flexibility in the curriculum without the loss of depth or motivation which is characteristic of specialization, encouragement of diversity in engineering education, more effective programs for continuing education, and a response to new developments in technology that goes beyond the assignment of new labels.

INTRODUCTION

The engineering profession is currently in the throes of a very thorough re-examination of its practices, status and goals. Continual re-examination and revision is a characteristic of engineering education but the engineering profession as a whole re-examines itself in a more periodic and dramatic fashion. This process involves much self-recrimination and is carried out in full view of the public. The primary result is a new set of directions and goals, or rather many sets of directions and goals. A secondary result is a very confused public, including our immediate colleagues in the universities and other professions.

SOME SHORTCOMINGS

I will first note some of the problem areas which have been identified by the current self-study.

(1) **Engineering is very much in the public eye, but our image is not very good.** Engineering is much harder to explain to the public than science and we make far less effort.

My companions today in the airport limousine fouled the air with cigarette smoke while they cursed the engineers (and perhaps legitimately) for allowing pollutants to pour out of the refineries we were passing.

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The public sees us as the generator of air pollution, weapons for mass destruction, traffic snarls, planned obsolescence of automobiles and appliances, sonic booms, etc. They do not realize that we hold the only hope for alleviation of these problems. Nor do they know how to seek or utilize our services in their behalf.

(2) **The humanists and social scientists are openly pleased at our disgrace and have little appetite for cooperating with us.** They are afraid of us and grandly contemptuous of a subject they do not understand. Aristotle in his *Politics-VIII* said, "Occupations are divided into those which are fit for free man and those which are unfit for them; and it follows from this the total amount of useful knowledge imparted to children should never be large enough to make them mechanically minded.

"The term mechanical should properly be applied to any occupation, art, or instruction which is calculated to make the body, soul, or mind of a free man unfit for the pursuit and practice of goodness. We may accordingly apply the word mechanical to any art or craft which adversely affects man's physical fitness, and to any product which is pursued for the sake of gain, and keeps man's minds too much and too meaningfully occupied."

Robert Hutchins is quoted¹ as saying recently that engineering schools should be stamped out. It is unlikely that we will convince the classicists of the merits of engineering even in another 2000 years.

(3) **Industry frequently acts as if it has no stake in the health and future of engineering.** It complains about the direction of engineering education and research and about the influence of the federal government, but defaults in the support of engineering education. It contributes preferentially and publicly to the colleges of liberal arts. It complains at the shortage of engineers but does not work hard to encourage students to take engineering. It emphasizes that advancement only comes through management and encourages engineers to divert to business administration. It offers a strong financial incentive to students to continue to the doctorate and discourages the practice of engineering with a bachelors degree by treating them as sub-pro-

professionals. I am quite aware of the many positive contributions of industry, but that is not our concern tonight.

(4) **Engineering education has itself taken some false directions.** Much engineering research in universities is merely imitative science. The recent change in name from Metallurgical Engineering to Metallurgy in my University acknowledges this development. The employment of new Ph.D.'s without industrial experience creates a closed loop that accelerates this trend. The core curriculum and the reduction in specialized courses have reduced the professional motivation of our students. "Mission-oriented" departments and curricula have been created which have no real justification other than temporary compatibility with Federal agencies that have funds to dispense. The addition of more abstract material to the curriculum has resulted in decreased comprehension by the students. Faculty attention has been increasingly diverted to graduate work and to those undergraduates who are potential graduate students. As a result of these several changes, the bottom half of the class is completely demoralized by the time they graduate. Again I have confined my remarks to the unfavorable changes.

(5) **We have discovered that technical achievements may create or aggravate social problems.** We advocate the addition of courses in the humanities and social sciences to ease our guilt. We even assert that engineers should themselves solve or prevent these social problems.

(6) **We are not yet prepared to intervene as a profession in behalf of the public interest.** For example, we silently design and operate plants that unnecessarily pollute the air and water instead of offering leadership to the public in this field.

(7) **We have discovered that our technical education rapidly becomes obsolete** primarily because of the outpouring of new technology and the revolution engendered by computing machinery. We have proudly announced to the public that we are obsolete. I do not recall scientists making this statement although they are in the same dilemma. We favor continuing education for our colleagues but are unwilling to undertake it on a meaningful level ourselves.

(8) **The engineering students must withstand the contempt of their fellow students in the liberal arts.** They are often neglected by the faculty. They are advised that they are second-class citizens unless they go to graduate school. They are told by industry that managerial skills are far more important than technical skills. Now they hear the self-recriminations of the profession. They are reacting as might be expected. They are "chickening out" of engineering in large numbers into science, business, medicine, law, etc., or are phasing out of engineering practice by continuing to the Ph.D. and seeking a career in teaching and/or basic research.

These are some of the problems we have identified. What are we doing about them?

THE GOALS STUDY

Engineers Council for Professional Development requested and the National Science Foundation funded a study of the goals of engineering education. Unfortunately despite the vast ex-

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penditure of funds and effort by the American Society for Engineering Education, the report^{2,3} which has resulted from the study does not state goals with which the profession can identify.^{4,5,6,7} It concerns itself instead with the labels and mechanics of education. Acceptance of the specific recommendations of this report would aggravate rather than alleviate the above-mentioned problems of the engineering profession and engineering education.

The preliminary version deprecates the baccalaureate degree outright, the interim version by implication. The authors would withhold professional acceptance from a would-be engineer until he had been awarded a masters degree. However they would award the masters degree in engineering for essentially the same effort as now required for a baccalaureate degree in engineering—but spread over five years instead of four. A specious degree will hardly raise the quality or prestige of engineering education.

Specialization is condemned by the reports. Somehow knowing less and less about more and more is supposed to produce a better engineer. All experience is against this recommendation. A

few engineering administrators have given loud vocal support to unspecialized engineering education for years but it has not gained general acceptance. Chemical engineers have protested this trend because they have learned through bitter experience that the core curriculum and general engineering result in the minimization of chemistry and hence in the elimination of chemical engineering at both the undergraduate and graduate level.

Mission-oriented programs are favored over the technically-oriented programs. This approach gains much public attention and attracts the opportunists. However interdisciplinary problems are usually solved most effectively by teams of specialists who have some knowledge in depth in the fundamentals which are common to all problems—new or old, of large or small scale.

One of the strengths of engineering education has been its diversity. Students are offered a different education by different schools and new approaches are tested in practice. The Goals Report would make every school conform to a single pattern—and to one that has already been tried and found wanting.

A significant factor in the continual improvement of engineering education has been the accreditation process conducted by an organization of the professional societies—Engineers Council for Professional Development. The recommendation that accreditation be shifted from a professional to an institutional basis on the whim of the institution would certainly undermine the strength and value of this activity. It would also eliminate the role of the professional societies in accreditation.

The report recommends increased course work in the humanities and social sciences. We all agree that the engineer should be cultured and should be aware of the social consequences of his work. It is questionable whether these objectives would be accomplished merely by forcing more ill-taught courses down the unwilling throat of the student.

The report identifies the weakness of engineers in written exposition and then provides an excellent example of poor logic, poor writing and poor organization.

Clearly, the Goals Report fails to provide valid guidance for the improvement of engineering education. Unfortunately the prestige of the sponsors of the report will result in more attention and acceptance than the report itself merits.

The effort expended on the Goals study has wearied and discouraged us. Nevertheless, we must recognize that its failure forces us to assume the burden of formulating new and more acceptable goals.

NEW DIRECTIONS

In what direction should we go? What goals should we set? Once we have stated the problems, as above, the solutions are evident, even though difficult.

We must explain our capabilities, methods and goals to the public. We must act as professionals, not merely as employees of the public, the universities and industry. We must learn to build the public and the social sciences into the loop of our activities rather than operating independently. We should neither ignore the social aspects of our work nor naively try to solve the social problems ourselves.

We should spend less time reciting our belief in continuing education and more time developing sound programs, not just as a fad, but as an accepted part of our professional life. Industry must give greater encouragement and support to such activities. The universities and professional societies must cooperate, not compete.

We must make engineering a more attractive profession to the youth of today. We must encourage him to choose engineering education. We must nurture him as a student. We must treat him as a professional when he practices engineering. We must recognize that he listens particularly to our public statements and watches our public behavior and that he has virtually no other source of information on engineering. Industry has a great opportunity here.

We must motivate and prepare students for careers in engineering as well as in graduate school.

We must motivate students to develop an interest in and an understanding of the humanities and social sciences, particularly as they relate to engineering.

We must increase the flexibility of our curricula without losing the depth which is characteristic of specialization.

We must encourage diversity of objectives and programs in our universities and we must study the results of experiments in engineering education.

We must prepare our students for careers in the new fields of activity and need such as bio-

engineering, medical-engineering and urban transportation. We should do this by inclusion of the appropriate fundamentals in the curriculum rather than by the creation of new curricula and new labels.

Industry must recognize its stake in engineering education and provide support by word and deed. It must treat engineers more consistently as professionals and even afford them some freedom for dissent. It must permit and encourage them to retain their identity as professionals.

CONCLUSIONS

Engineering has an uphill battle for survival in the face of

- Public misunderstanding
- Congenital suspicion, fear, and dislike by the humanists
- Half-hearted support by industry
- Second-hand support by the government
- Unconstructive diversions from within as per the Goals Report
- The continual burden of response to new problems and technology

Nevertheless, to paraphrase the words of William Faulkner in acceptance of the Nobel Prize for Literature, engineering will not only survive, it will prevail. It will prevail because it holds the only hope for the solution of the major problems confronting mankind. It will prevail despite the attacks of its friends and enemies because it has demonstrated the capability of changing and evolving—not through exhortation or formulas, but through response to needs.

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