Engineering and Society Programs in Engineering Education

Engineering education requires greater integration of values derived from liberal education.

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It has become increasingly apparent that engineering graduates are poorly equipped to deal with the complex social effects of most engineering activities. Partly in response to this phenomenon, there has been an expansion of academic programs that focus on the relationships of science, technology, and society (STS). This general area of interdisciplinary studies encompasses topics such as science and technology, policy, implications of science and technology in terms of ethical and human values, science and humanities, technology assessment and forecasting, and technology and human affairs. When such studies are fostered by engineering schools, I have labeled them "engineering and society (ES) programs." Although it seems obvious that these programs have special relevance to engineering, it has not been clear why they have been so rarely incorporated into engineering education. This article is an attempt to explain why this has been the case and to suggest some ways by which the situation might be changed.

Contemporary engineering education can be characterized as consisting of three principal parts: basic sciences (for example, mathematics, physics, and chemistry); liberal studies (for example, humanities and social studies); and engineering studies (for example, electrical and civil engineering). Underlying the curriculum is the assumption that engineering education prepares students to function effectively as practicing engineers. Although there is great interest in preparing students for research careers, only rarely is an undergraduate student permitted to depart from a curriculum prescribed by one of the fields of engineering. The interaction between the basic sciences and subjects within the engineering discipline is enhanced by a long-standing tradition of prerequisite courses. Liberal studies (which may occupy 15 to 25 percent of the curriculum) have a tenuous relationship with the other aspects of the curriculum. I believe that the importance of STS-ES programs to engineering education is that they provide a means by which liberal studies may be integrated into the curriculum.

"Design" is one educational activity in which the student is given the opportunity to integrate and synthesize the learning and experience that precede it. According to the Engineers' Council for Professional Development (ECPD), (*1*, p. 3).

> Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. Central to the process are the essential and complementary roles of synthesis and analysis.

If the design process is to be useful, it must be understood that the solution to any real engineering problem is never merely technological, that the ends to which the engineering solutions are means are never hard and completely defined, that the engineering solutions make a difference to these ends, and that the engineer must therefore comprehend their social, nontechnological contexts (*2*).

If engineering education is to deal more effectively with the design process and if we are to better prepare our students to perform these tasks, then engineering educators must begin to address these issues in the context of their professional work. I shall attempt to show how engineering education, by striving to provide a strong analytical base, has ignored much of the professional development of the student. I shall also examine the issue of professionalism in undergraduate education in order to try to explain why engineering students do not derive greater benefits from their liberal education courses. Finally, I shall suggest that engineering schools need to integrate or internalize that learned in liberal education courses if future engineers are to understand the complexity of the society in which they will practice. An excellent model for achieving these goals is provided by STS or ES programs that attempt to deal with many of these concerns through research and teaching.

Strengths and Weaknesses

Engineering education has moved monotonically to the development of courses and entire curricula that give primary (and in some cases exclusive) emphasis to analysis (*3*). For the past two decades, engineering colleges dedicated themselves to preparing students to cope with the relevance to engineering of an accelerating expansion of modern science and technology. The influence of the sciences on engineering programs has been strong. Practically all engineering faculty recruits have had doctoral level graduate science (or applied science) and research training. The nature of research support provided by federal agencies and foundations has provided additional impetus and credibility to faculty members with "analytical" interests (*4*). Faculty promotions and advancement have come more and more to depend on the quality of the analytical content of their research.

Engineering courses that drew heavily upon experience yielded to courses that employed models and analytical techniques and that emphasized methods of analysis. Descriptive material was replaced by "new" or additional scientific information.

Generally, members of the faculty seem to consider it desirable that engineering education should become a more analytical, methodological, and objective course of study; there is little doubt that much has been accomplished in achieving these goals. The evolution of a more analytical curriculum is the result

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of efforts of faculties to create an educational environment that supports their interests and strengths. One consequence of an analytically oriented faculty (and curriculum) has been a significant decrease in emphasis on preparing students to deal with complexities of engineering work.

Analysis and Design

There is no question that analysis is an essential ingredient of engineering education, but both faculty members and students must remember that these are means rather than ends. All too frequently faculty members (and their students) have become so expert and so dependent on analytical crutches that it often appears that the crutch has taken command of the object it was intended to support. The educational experiences of engineering students can lead them to believe that the real world consists of nicely structured problems for which the boundary conditions and constraints are given and explicit. Students thrive when they are asked to find solutions to problems that are restricted to a physical-chemical-biological domain, but they exhibit distress when faced with unstructured situations (*5*). Engineering educators and their accreditors (ECPD) have taken special pains to assert that analysis is an essential but not sufficient aspect of engineering education. Thus, much lip service is given to design (*1, 6*) as the synthesizing aspect of the curriculum.

The teaching of design is not a trivial matter. To improve the quality of the teaching, numerous suggestions and experiments have been made: faculty leaves of absence with industrial or consulting firms, visiting practitioners in residence on campus, release time for consulting activities, special kinds of teaching formats proposed by inspired and creative educators. Unfortunately, nothing really seems to work.

In my view there are three primary reasons why design is often taught badly: (i) Members of the faculty are not adept at design; more important, they are better at analysis. (ii) Design is difficult to teach; teaching analysis is easier. (iii) In spite of all the discussion about design, it is not considered to be very important in terms of how faculty members are regarded by their peers.

The ECPD definition of design (*1*, p. 3) suggests the following fundamental elements in the design process: ". . . establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation." In addition, ". . . sociological, economic, aesthetic, legal, ethical, etc. considerations . . ." need to be included in the design process (*1*, pp. 3–4).

In light of the restrictions on student and faculty time and resources, faculty members frequently question whether design problems can be treated in a classroom setting. Much of the problem results from the value-oriented perspective that envelops design issues. Identifying needs, understanding objectives, and establishing appropriate criteria for evaluation are all infused with social, political, ethical, and technological values. There are no absolute responses appropriate to these issues. Analysis can, at best, enrich our understanding and improve the bases upon which choices are made. Solutions to design problems can only be graded better or worse, since the number of possible solutions is infinite.

Engineering faculties, striving to be objective and analytical in their academic pursuits, are frequently troubled by the direct assault on their sensitivities created by design situations. Analytical expertise plays only a small, albeit vital, role, while judgment plays a dominant role.

Although it may not be possible for engineering educators to train accomplished engineering designers, we have a real responsibility to prepare students so that they can effectively participate in the design process. The greatest failing of modern engineering education is that we do not provide students with sufficient opportunities to make decisions and thus to develop the judgmental skills they will need.

It is neither necessary nor desirable to eliminate courses that develop the student's analytical skills. What is required is to encourage the faculty to give significant emphasis to the context in which real engineering issues arise and to provide problem exercises that require the student to make choices, to exercise judgment. The student should be expected to respond to these situations in two ways: (i) to demonstrate that they are able to derive correct analytical solutions to the problems presented (which can be evaluated as right or wrong), and (ii) to select and argue for a solution that best responds to the issues concerning values that are contained in the problem setting (which could be evaluated on an ordinal scale on the basis of the quality of the arguments provided). Needless to say, this procedure is not an appropriate model for every course. Rather, it is an example of how judgmental issues might be injected into some courses.

Societal Issues

As a group of specialists we have produced an educational program that defines the whole as the sum of its parts. Whatever attention is given to "engineering" is through "design" courses, in which it is hoped that the student will spontaneously integrate his technical and nontechnical knowledge.

If the members of an engineering faculty are unable to develop judgmental skills in their students by directly addressing the value issues that pervade engineering, they have abdicated their professional responsibilities as engineers and educators. Further, requiring that approximately one-fifth of the coursework of engineering students be in liberal studies will continue to be a formality, viewed by both the students and the faculty as irrelevant or unimportant to engineering. It is possible, however, to create an atmosphere in some courses in which the interplay of technical and societal issues can at least be discussed. We can impress on students the importance of developing good judgment and can help them identify some issues of concern or importance so that they can begin to internalize these matters as engineers.

The Course Syndrome

Those engineering faculty members who are concerned with these issues often respond by advocating that new courses be offered. Such courses usually reflect the interests and competences of the teachers who give them. Sometimes they are taught by teams, sometimes they are interdisciplinary, and sometimes they are solitary enterprises. They all seem to disappear as soon as the faculty member's interest wanes or the pressure of other matters exerts its influence, perhaps because whatever commitment to these efforts individual faculty members may have becomes more personal than institutional. (By institutional I refer to a faculty member's commitment to a topic because it is prescribed by a curriculum; as in courses in physics, mathematics, engineering sciences, and so forth.) In general, if a faculty member has a personal interest in topics that might fall under the rubric "engineering and society," his colleagues will rarely discourage him from participating by denying these courses an approved status. However, such approvals are viewed more as a professional courtesy than as a form of an institutional commitment. The teachers who do become involved in these efforts quickly perceive that while their good intentions may be welcomed they are not treasured by their colleagues. This awareness results in less than the dedicated scholarship one would hope to be reflected in any area of study and gives rise to complaints of charlatanism and superficiality. While it is relatively easy to make comments about superficiality, it is not quite clear how good scholarship is characterized or defined. The entire area of STS-ES is so new that adequate means of assessment are lacking. There are numerous examples of courses of all types and styles that are offered in STS-ES programs in many universities in the United States (*7, 8*). In some cases these courses have stimulated faculties to establish formal curricula (and grant degrees), but in most institutions the courses are either extensions of humanities and social sciences programs, or they are supplementary offerings within engineering or science units.

Frequently the faculty members involved in these efforts gather together either as an informal group, or they have some official program status in their institution. These groups may consist of faculty members from many disciplines who like to think of themselves as interdisciplinary. Such groups frequently struggle with the problem of status within academe, a struggle reflected in their concern with granting degrees, becoming a department, and so on. It is not clear that achieving these ends is in the best interests of the faculty members involved, the institution, or the students.

I do not believe that creating new degree-granting programs can aid engineering education. It is not that I object to training individuals who are primarily interested in STS-ES. My major objection is that by creating yet another division of scholarship we would exacerbate the problem of excessive specialization which already compromises the quality of engineering education. Programs in the humanities and social sciences are frequently criticized as not providing quality courses for students who do not intend to major in these areas. Similar comments are made about courses in physics, chemistry, mathematics, and engineering. Specialization (with its attributes and deficiencies) occurs in all sectors of academe whether new or old. Under the premise that engineering must learn to internalize STS-ES matters, establishing another specialty would provide an STS-ES program with enough detachment that it, too, would be conveniently ignored.

Professional Engineering and Liberal Education

If one accepts the premise that the engineer should be a well-educated person, it follows that engineering faculties have a major responsibility for the instructional goals by which this end may be achieved. The Grinter report details the attributes of the well-educated engineer (*9*, p. 35):

> He must be not only a competent professional engineer, but also an informed and participating citizen, and a person whose living expresses high cultural values and moral standards. Thus, the competent engineer needs understanding and appreciation in the humanities and in the social sciences as much as in his own field of engineering. He needs to be able to deal with the economics, human, and social factors of his professional problems. His facility with, and understanding of, ideas in the fields of humanities and social sciences not only provide an essential contribution to his professional engineering work, but also contribute to his success as a citizen and to the enrichment and meaning of his life as an individual.

By accepting this credo, the engineering community expressed what it hopes to achieve in developing the foundations on which one may build a professional career.

Much ado has been made about the driving spirits of professionalism and specialization that have invaded the colleges and universities, one consequence of which is the demise of liberal education. (These concerns are not restricted to engineering but embrace all programs that strive to prepare specialists.)

Jacques Barzun characterized the situation as one in which the great scholar teaches undergraduates as if they were going to be specialists in the same field; younger faculty, under pressure to show productivity in research, teach only courses related to their specialties; undergraduates themselves choose a major directly related to their career goals in the last 2 years of college (*10, 11*).

The students' apparent lack of interest (largely resulting from competition from more directly professionally relevant courses) tends to devalue the time or energy invested in liberal courses (*11*, p. 55).

> No undergraduate can believe that he is going to be at the same time an anthropologist, a Milton scholar, an historian, and a chemist. Yet that is what modern teaching assumes about him in successive hours of the college day. . . . The motive to study is inevitably lacking in at least three out of four classes when so conducted. . . .

The Grinter Report, apparently sensitive to these issues, admonishes the liberal arts *and* engineering faculties to be responsive to their educational objectives (*9*, p. 40).

> Teachers on the liberal arts faculty should distinguish between the mission of developing scholars and conducting research in their own disciplines, on the one hand, and their obligation, on the other hand, to make available the knowledge and values that are significant for students majoring in other fields. . . . This requires that the faculties of the humanities and the social sciences regard the teaching of engineering students as challenging and rewarding, and that engineering faculty members adopt an appreciative and understanding attitude toward their colleagues in the liberal arts.

Some Issues in Learning and Teaching

Bell provides an illuminating taxonomy of the different principles that govern the acquisition of knowledge in the sciences (including engineering), the humanities, and the social sciences. He perceives the acquisition of knowledge in the sciences as largely *sequential*. The student acquires knowledge in measurable steps that build on each other. In the humanities, understanding is *concentric*. Common themes such as the discovery of self, the nature of tragedy, and the variety of love are approached by different paths, and understanding develops through experience. *Linkages* underlie learning in the social sciences, in which an understanding of one phenomenon, such as an economic system, is possible only through an understanding of related phenomena, such as the political climate (*11*, p. 141).

If engineering students are required to spend at least 80 percent of their courses in a sequential learning environment, it seems obvious that they might encounter some difficulty in adjusting to concentric and linkage patterns of acquiring knowledge. Perhaps we expend insufficient effort in helping students understand these different principles but instead expect them to adjust flawlessly and rapidly as they go from class to class.

An additional factor that affects engineering student and faculty attitudes toward the liberal education content of the curriculum is the "result syndrome" of engineers which contrasts with the focus on "process," the major preoccupation of humanistic and social studies. Whether engineers are predisposed or conditioned to seek solutions is less important than the impact of this attitude on the content and scope of their liberal education. Thus, as far as engineering students are concerned, it seems that the lack of special interest in liberal education may be as much related to the different perspectives of the students and the liberal arts faculty as it is to the pressures to specialize suggested by Barzun (*12*).

Although professionalism in undergraduate education is often viewed as an evil, colleges and schools of engineering usually identify themselves as institutions that provide undergraduate professional training. Engineering, compared to some of the other professions, is unique in that an undergraduate education is the principal vehicle for individuals entering the profession.

Many engineering educators have argued that professional training cannot be provided in 4 years, and they have suggested that a minimum of 5 years of training should be required for the first engineering degree. Although engineering educators usually urge students to enroll in the fifth year of training, only a few students pursue this path (*13*). These unsuccessful attempts to expand the scope of undergraduate engineering education provide sufficient evidence that a 4-year curriculum is and will continue to be the norm (*14*).

Apart from periodic pronouncements and some discussion usually framed in "Goals Reports" (*15*), engineering faculties have been too preoccupied to reexamine the objectives of a 4-year professional program in engineering. More importantly, if one accepts principles espoused by these reports, articulating those objectives within a particular institution is the responsibility of that faculty. Because of changes in faculty, program emphasis, and institutional resources, these issues should be a continuing concern of the faculty. Regrettably, few faculty members are prepared to invest the time and energy needed to address these conceptual issues even though they are responsible for establishing the curricula.

Under such conditions it is difficult to entice the engineering faculty to examine the issue of the liberal education in any more substantive way than to argue about the number of credit hours that should be required for engineering students. Dealing with content and methods used in these courses is all too frequently viewed as being beyond their ken. It is difficult to understand such a position if the engineering faculty maintains and fosters professionalism in its educational programs. Because of competing demands on faculty time (and primary allegiance to one's own subject area), we have tended to view our curricular responsibilities in liberal studies as being adequately discharged by sending our students to our colleagues in the humanities and social science faculties.

If engineering schools are to sustain their professional orientation, their faculties must be prepared to accept responsibility for the content of the total curriculum. We cannot discharge these responsibilities by sending our students elsewhere. Further, the faculty has an obligation to monitor and relate the students' experiences in their educational environment to the goals and aspirations of the profession lest we allow engineering education to sink into ignominy.

Specialism

The concerns about specialization, although not new, are particularly important in discussions about general education. David B. Truman (*16*) comments:

> In an age increasingly reliant upon specialists it is altogether too easy to leap to the conclusion that training in the skills that lie at the core of a specialty is all there is to the matter and to ignore the point that this is not the only or, surely, the most responsible way to educate the kinds of specialists that society will need.

Truman and Bell agree that the central problem is how to educate a person capable of understanding the moral and political consequences of his actions as a specialist, a person with relevant breadth rather than limited and dangerously irresponsible competence. Alfred North Whitehead also directs our attention to the dangers inherent in specialization, which he believes produces "minds in a groove" (*17*).

In spite of these concerns, it is vacuous to decry specialization and its inherent dangers, since there is little likelihood that the trend will be reversed. The many forces, within and without the university, that entice individuals into early specialization provide faint hope that implementing a general education curriculum can have much effect.

Bell (*11*) suggests that the trend toward specialization cannot be wished away but should instead be directed to satisfy both intellectual and practical needs. He advocates a more liberal conception of specialization itself, one that emphasizes a grasp of the discipline and a grounding in methods. Such a specialist would be able to relate a particular task to the general intellectual field and would also be able to adapt to the needs of a rapidly changing society.

While it may be desirable for students to seek liberal education for its own sake, it is also reasonable to expect educators to supply some motivation to help students escape the tunnel vision that specialization produces.

Students who spend most of their time in courses which emphasize sequential learning patterns and who are driven to seek results should not be expected to turn to liberal education (which involves concentric and linkage patterns and major concern with process) with much enthusiasm. Students' time and attention are almost all committed (*18*), and considerable aid and encouragement are needed for them to understand the relevance of liberal education. An engineering curriculum is almost totally prescriptive except that (i) students can choose the fields or subfields in which they specialize, and (ii) they can choose (usually from an approved list) (*19*) liberal education courses which fulfill a liberal elective requirement.

Suggestions

I offer three suggestions that I believe will help engineering education address the problems I have identified (*20*). These focus on two issues: (i) the liberal elective requirements, and (ii) the need for explicit commitment by engineering faculty members to engage in "engineering and society" issues as an integral part of the teaching and research program of the school or college.

The liberal electives. The liberal elective (requirements) specified by most engineering schools should be reevaluated by the engineering faculty in concert with the liberal studies faculty. The time has come for the engineering faculty to begin a real consultation with their colleagues pertaining to mutual concerns for the liberal education of engineering students. Through such discussions we can better understand the difficulties engineering students face in deriving the greatest benefits from their liberal education courses and perhaps devise ways by which the benefits may be increased. It is to be hoped that the engineering faculty can begin to comprehend how it may expand "design" courses to encompass some of the problems regarding values that are frequently preempted by the emphasis on technology. The experiences of many STS programs with these problems should be valuable in these endeavors (*7*).

History—a required liberal course. I propose that all students be required to take a course in history during the first term of the freshman year. The course would be designed to help the student develop (i) a perspective of the importance of liberal education to professional development, (ii) an appreciation of the pervasive effects of technology on the social and cultural development of society, and

(iii) an awareness of an individual's potential for contributing to these effects.

My suggestion for a required history course was stimulated, in large part, by Bell's comments about the role of the study of history in general education (*11*). Bell suggests that the study of history demonstrates that social situations are complex mixtures of things that can and cannot be changed. History provides a "vocabulary of reference" that can stretch the imagination and prevent the misinterpretation of events. It emphasizes the importance of putting ideas in context, identifies the relevant events that shaped the present, and provides a way of analyzing past and present actions. Further it is important for the student to ". . . see history as the efforts of peoples and societies to deal with some recurrent problems of social order . . ." and to develop an ". . . understanding of basic social processes" (*11*, p. 173). These general objectives for the study of history seem to be especially appropriate to the education of engineers.

We should all be distressed by the ignorance displayed by engineering students of the roles their predecessors have played in their own lives and by their lack of sensitivity to what they as individuals with engineering skills can do for and to others.

If one purpose of this history course is to motivate students for their future course experiences in liberal studies, the way it is taught is important. A course for engineering freshman should place less emphasis on monumental events and those extraordinary individuals who were the principals in carrying them out and more on how the drones helped to make these things happen. The study of history should help students to relate what they will be doing as future technologists to what has been done.

Students are wise enough to recognize that creating monumental events will be exceedingly difficult for them to do. Therefore, descriptions of people such as Edison, Bell, Roebling, and Fermi, while interesting, have little relevance to their own self-images. In some way, the supportive technology that surrounded these historical events should be identified and understood. Future major breakthroughs in the sciences will depend on a large and complex technological infrastructure as evidenced by the nature of contemporary research in physics, chemistry, biology, and engineering. Unfortunately, the elegant (but uncomplicated) kinds of discoveries that were so important to the development of modern science and technology will rarely, if ever, be repeated.

The preparation and presentation of such a course is no small task. I do not propose a history of technology course but a study of history that explicitly deals with the role played by technology. The periods to be covered and the scope and format for the course are best left to the historians who will teach it. The lecturer will have to be outstanding, one dedicated to teaching and motivating not future historians but engineers who need to ". . . see history as the efforts of peoples and societies to deal with some recurrent problems of social order . . . and . . . [to present] the principles of historical explanation and the nature of evidence, as ways of understanding basic social processes" (*11*, p. 173).

Although I have highlighted history, similar criteria could be established for many other courses in the humanities and social sciences. Courses in philosophy (ethics), anthropology, and political science are certainly likely candidates. Such courses should also be of considerable importance to students other than engineers.

Engineering and society. Conditions are propitious for engineering schools to devote some of their own resources to dealing explicitly with the interactions of technology and society. Essentially, I would characterize the array of STS programs as undeclared efforts to bridge the two cultures. To accomplish this end faculty members with explicit responsibilities for these tasks should be appointed to engineering departments.

Since many educational institutions already support such activities, no one need be concerned with acting precipitously in committing resources to such a program. In spite of the vigor of many programs, there is considerable uncertainty as to how one best initiates and sustains such an effort.

Those programs which appear to have been of distinctive quality almost always involve faculty members who are highly regarded by their colleagues, not so much for their scholarship in STS-ES matters but, rather, because they are excellent engineers, chemists, philosophers, or physicists. Engineers in the program should also have demonstrated their scholarship in areas outside of their specialty and be intellectually committed to STS-ES issues. Establishing distinctive professorships for them would give credence to their responsibility for enhancing STS-ES activities within engineering. Engineering should nurture its own Sir Eric Ashby, Kenneth Boulding, and René Dubos and encourage such individuals to challenge, inspire, and guide it in these new directions. Seeking them out is not easy and we won't always make the right choices, but the difficulty does not mean that it is not worth doing.

Conclusions

There is no doubt that individuals with engineering training have had and will continue to have vast decision-making responsibilities to our society. Whether the engineering student elects to pursue a technical specialty as a career or to branch out into other career opportunities, the effect of the engineering educational experience is an important determinant of how well the decision-making responsibilities will be carried out.

The role of design in the education of engineers should be expanded to include more ES issues in order that the future practitioners can be better prepared to make decisions. Such issues are part of the design process. Through these changes we will have taken significant steps toward creating an environment that facilitates the internalization of liberal learning and thereby better prepares the engineers for the future.

References and Notes

1. "Objectives and procedures for accrediting programs in engineering in the United States, 1974/75" (Engineers' Council for Professional Development, New York, 1975), p. 3.
2. S. M. Brown, Jr., personal communication.
3. By "analysis" I refer to the process by which we partition the subjects of an engineering curriculum into its elements in order that students can better understand its essential features. By comparison, "design" is the process by which we strive to integrate all the elements.
4. In this context it is interesting to observe that the National Science Foundation established the RANN (Research Applied to National Needs) program, which focused on applied problems. This program encouraged the use of elegant analytical techniques, in part to demonstrate their relevance, importance, and utility.
5. Engineering efforts are usually initiated by a statement of social or personal objectives, which are eventually transmuted into specific technical issues. Thus a river crossing may take the form of a bridge, a ferry, or a tunnel. Bridges can be figuratively decomposed into various kinds of trusses and the individual members that make up a truss. In general, a problem is given more structure as it is decomposed.
6. In contrast to the ECPD definition (which I believe appropriate), design in undergraduate engineering education is primarily synthesis. The synthesis is directed toward combining what has been learned in "analysis courses" but little beyond that.
7. E. D. Heitowit, J. Epstein, G. Steinberg, "Science, technology, and society: A guide to the field; Directory of teaching, research and resources in the U.S." (Cornell University Program on Science, Technology and Society, Ithaca, N.Y., 1976.)
8. Some initial efforts directed toward assessing the objectives have been undertaken. See J. C. Mathes and K. Chen ["Science, technology and society and values program: Dichotomies of educational objectives" (Univ. of Michigan, Ann Arbor, 1976)].
9. "Report of the committee on evaluation of engineering education", L. E. Grinter, Chairman, *J. Eng. Educ.* **46**, 26 (1955).
10. J. Barzun, *Am. Scholar* **33** (No. 2), 212 (1964).
11. D. Bell, *The Reforming of General Education* (Columbia Univ. Press, New York, 1966).
12. This attitude is demonstrated by engineering professionals who, when criticized for their "de-

signs" or for the technological solutions to social problems, occasionally turn to their critics for suggestions or alternatives. Alas, the critics have no technical modifications to offer but focus their challenges upon the presumptions, assumptions, and consequences of the proposed result. The fact is that some problems are not amenable to technical solutions, but trying to solve them through technology is characteristic of Western society.
13. Students who complete a fifth year usually receive a "professional master's degree."
14. I am seeking to avoid a tangential discussion of how long it takes to train an engineer, which is an important topic but not especially relevant to my thesis.
15. Reports issued by Committees of the American Society for Engineering Education on "Goals of Engineering Education."
16. D. B. Truman, foreword of (*11*), p. ix.
17. A. N. Whitehead, *Science in the Modern World* (Macmillan, New York, 1960), pp. 282–83.
18. Their commitments are formed by the students' attitudes, the attitudes of their engineering teachers, and by the curriculum.
19. The fact that many engineering schools have to establish (for the faculty advisers and students) lists of courses that are acceptable as liberal electives is incriminating evidence that the role of liberal education is poorly understood.
20. I make these suggestions with some trepidation since I recognize that the appropriateness of any proposal depends upon the intellectual, emotional, and financial environment in which it is evaluated. It should be recognized that there are no actions that will in themselves remedy these problems. Much of the problem is attitudinal, and attitudes are not easily or quickly affected. Finally, while these proposals may appear to be prescriptive, they should be viewed more as classes of actions that might be considered. If engineering faculties are prepared to give these issues the attention they deserve, I have no doubt that many other proposals will evolve.
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NEWS AND COMMENT

Guillain-Barré: Rare Disease Paralyzes Swine Flu Campaign

The troubled influenza immunization campaign—which had previously survived production delays, insurance squabbles, sporadic scientific criticism, and a scare caused by the deaths of three elderly Pittsburgh residents shortly after vaccination—ran into its most serious problem yet as 1976 drew to a close. On 16 December the campaign was temporarily suspended because of reports that some 51 individuals among an estimated 50 million who received flu shots subsequently came down with a poorly understood paralytic disease known as the Guillain-Barré syndrome. (The number of cases reported has since climbed above 200.)

The discovery set off a wave of denunciations of the immunization campaign. The Washington *Post* decreed the program a "fiasco." A columnist for the *New York Times* called it a "sorry debacle." Political cartoonists lampooned the program with glee. And Sidney Wolfe, head of Ralph Nader's Health Research Group, called for the resignation of David Sencer, director of the federal Center for Disease Control (CDC), "the main person responsible for promoting this costly" and "ill-conceived" campaign.

But the reaction to the Guillain-Barré cases may have been premature. At this writing, CDC is still in the midst of an investigation to determine what relation, if any, the Guillain-Barré syndrome has to the vaccination campaign. Some scientists who support the immunization campaign believe that, when all the facts are in, the vaccinations may not be implicated in the syndrome. Others believe that they will be implicated but that the risk to those vaccinated will be too slight to justify abandoning the campaign altogether. The latest figures show, according to Sencer, that the risk of suffering Guillain-Barré disease severe enough to cause permanent injury or death is only 1 in 1 or 2 million vaccinations. That's far less than the threat posed by influenza epidemics, which, in a typical year, kill tens of thousands of people.

The current situation differs markedly from the scare that followed the earlier deaths in Pittsburgh. In that case, federal officials were able to argue that a few deaths among elderly vaccinees around the country was not caused by vaccination but was simply a statistical coincidence—a certain number of old people will die every day whether they get flu shots or not. But the statistics on Guillain-Barré syndrome were not so reassuring. The government's top health advisers noted an ominous bulge in the incidence of the disease, which suggested that there might well be some connection with vaccination.

The effort to unravel the current situation has been complicated by the fact that relatively little is known about the Guillain-Barré syndrome, which is sometimes referred to by such other names as "French polio," "ascending paralysis," or "acute idiopathic polyneuritis." The victims typically develop symmetric weakness in the limbs, loss of sensation, and diminished reflexes. Most recover with no lasting effects, but some suffer permanent paralysis or respiratory difficulties that lead to death. There are conflicting reports concerning the nature of the disease and its patterns of attack. Virtually the only information about long-term incidence of the disease in this country is derived from a Mayo Clinic study of Guillain-Barré cases in Olmsted County, Minnesota, between 1935 and 1968—a frail base indeed from which to estimate the syndrome's pattern of occurrence in the country as a whole. The cause of the disease remains unknown. A 1966 review of some 1100 cases of Guillain-Barré syndrome reported in the French, English, and American scientific or medical journals indicated that one-third of the cases had no demonstrable cause. Most of the remaining two-thirds occurred after the victim had suffered an infectious disease, but 48 cases occurred after inoculations of various kinds, including one inoculation with influenza vaccine. Whether there was a causal relationship among these events is unknown.

The first cases of Guillain-Barré associated with the current immunization campaign turned up in Minnesota. Under a surveillance system designed to track the side effects of vaccination, CDC received a report on 19 November that four vaccinated individuals in Minnesota had come down with the syndrome. However, Minnesota health authorities investigated the situation and concluded that vaccination was not the cause. Then, about a week later, three cases were reported from Alabama, and soon another was found in New Jersey. These states—and eventually others as well—were asked to conduct active searches for Guillain-Barré cases among the vaccinated and nonvaccinated—chiefly by contacting neurologists or others apt to treat patients with the syndrome. By 13 December, enough preliminary data were in hand for CDC to conduct a conference telephone call with experts from other government agencies and the universities. The verdict was to continue the immunization campaign. "There was a unanimous view that there was not enough evidence to call a halt to the program," recalls one of the partici-