ChE book reviews

ENGINEERING EDUCATION AND PRACTICE IN THE UNITED STATES

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Faculty shortages, overcrowded classrooms, and inadequate equipment are diminishing the effectiveness of engineering education in the United States, according to this report from the National Research Council, a part of the National Academy of Sciences. The two-year $900,000 study was conducted by the NRC Committee on the Education and Utilization of the Engineer made up of 26 members about equally divided between education and practice. Funding came from NSF, several other government agencies, and a number of major corporations.

The study attempts to examine both sides of the engineering equation: education and utilization. In view of the present times, the tone of the report seems overly objective and its conclusions on the optimistic side. A brief discussion of the development of engineering in the United States is followed by an examination of the status of engineering today. In seeking an understanding of engineering's infrastructure, the report focuses on "organizing principles" and comprehensive flow diagrams.

Roughly one-fourth of the report's 123 pages are devoted to a critical look at the strengths and weaknesses of current engineering education. It is correctly noted that "the most critical and concerned attention directed at the engineering profession in recent years has focused on engineering education." On the other hand, the report fails to convey a sense of urgency in addressing the crisis of quality that it agrees exists in engineering education today.

The section of the report on education documents today's problems in a convincing manner. Engineering undergraduate enrollment has grown at least 80 percent during the last decade while in the same period, engineering faculty has grown only 10 percent. Engineering PhD degrees have decreased by 30 percent and one-third of these have been to non-U.S. nationals who make up over 40 percent of the graduate students in engineering. At the same time the pressures on engineering faculty have been aggravated by an increase in sponsored research of 50 percent in constant dollars. The pervasive problems of equipment obsolescence and the aging of physical plants are well documented.

The report describes a two-tiered system of engineering education that has been exacerbated by the current crisis. The first tier consists of institutions that are the major recipients of government funds for graduate education and research. They are seen as enjoying a distinct advantage that influences both graduate and undergraduate engineering education. The second tier consists of those institutions that have as their primary focus undergraduate education. Because both government and industry focus their funding on graduate study and research, these colleges are forced to depend on other appreciably smaller sources of funding. Approximately one-half of the B.S. engineering degrees are estimated to be granted by colleges in the second tier. The report concludes that separation of the two-tier system will widen unless both government and industry introduce innovative programs accompanied by more than token support.

Turning to curriculum, the committee concludes that undergraduate programs should provide considerable breadth across the disciplines of engineering and within each discipline. Actions called for include greater emphasis on non-technical education (greater exposure to the world of ideas), computer technology, orientation to the realities of the work world, and personal career management.

The committee could not reach a consensus about whether or not the four-year program leading to the first professional degree is any longer sufficient. Considerable support was found for a pre-engineering undergraduate program followed by a professional school program with the combination requiring more time than four years to earn the first professional degree.

The final section of the report offers a preview of engineering and its environment in the year 2000. The discussion is based on a careful analysis of the engineering workforce as it exists today. For working engineers, the report paints a rather rosy picture noting that the estimated 1.6 million engineers are among the "best paid of all non-self employed professionals," and that their unemployment rates are the lowest of any profession (2 percent). Looking to the future, the report states that "we are entering an era in which engineering will play a more dominant role than ever."

The report offers a 17-page executive summary but the reader settling for this will be poorly served. The summary includes recommendations selected from the report that are largely unrelated and of widely differing degrees of importance. The main thrust of the report is found in conclusions and recom-

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The idea of assigning articles for reading, as a partial assignment within a course, is often resisted by some . . ., a situation that sometimes results in a poor and deficient report.

semester who cannot meet face-to-face with another person to discuss clearly his or her point of view on any problem. There also exists more than one case of a student who is about to graduate but who does not feel comfortable speaking in front of his own classmates because of the dread of making a fool of himself. We have to learn how to overcome that drawback . . . it is not too late.

The assignment consists of the same five main parts for any course I lecture in, namely

1. **To read and understand the paper thoroughly. This involves knowing what theories, methods, equations, approximations, and applications are contained in the publication, and, of course consulting the literature when it is necessary.**
2. **To present an original contribution related to the subject of the article and to the topics studied in the course. Modifications, applications, and extensions of the subjects of the publication are appropriate for this part.**
3. **To present two numerical problems related to the topics of the article. The problems must be presented with detailed solutions. Originality and ingenuity are the main factors considered in the evaluation of this part.**
4. **To submit a written report about the article. The report must be original and should contain what the student understood about the subject. It should also contain the original contribution and the problems.**
5. **To prepare and give a talk in front of the class and the professor in which the main ideas, results, and conclusions on the subject are presented. There is a time limit of fifteen minutes for each student.**

Of these steps, the first one has always been the most difficult for my students, although they recognize that it is the most important part for developing a good contribution (step 2), inventing original problems (step 3), writing a good report (step 4), and giving a clear talk on the subject (step 5).

With points (2) and (3) my idea is to promote originality and develop creativity. With a new contribution, students create new situations, prove some of the proposed concepts, compare their ideas with others found in the literature, and speculate about the scope of the subjects. Inventing problems and then solving them is an exceptional exercise in which students test themselves on their comprehension of the publication. To invent a good problem, the ideas about the subject must be absolutely clear. Otherwise, the problems may result in unclear, ambiguous, and contradictory situations . . . in summary, a poor problem.

For the written report, I give my students several rules concerning the form and style of the report, but allow them maximum freedom on the subject itself in order not to limit their creativity or working capacity. Clarity, depth, and continuity in the presentation of the subject, originality of the written material, presentation and organization of the report, and quality of writing are the main factors considered in the evaluation of the report.

The importance of clearly transmitting ideas is self-evident. With a time limit of fifteen minutes for a talk, the students are forced to present the essence of the article, select the main equations, show the most relevant figures and tables, and discuss the most important conclusions and scope of the paper. Emphasis must be given by students to their own findings, their original contributions, and their application problems. Participation by the rest of the class is encouraged as a form of promoting discussion, enriching the presentation of the subject, and obtaining the maximum benefit from the talk. Clarity and continuity of the presentation, adjustment to the time limit, answers to questions from the class, and participation in other students' presentations are the main factors considered in the evaluation of this part.

The most important factor for making the idea work is to get students interested in what they are doing. To that end the professor has to adequately reward good work and punish poor work. Giving written reports and oral presentation an appreciable importance, say between 20% and 30% of the final grade of the course works well. The professor should also use strong and weak works as examples of what should and should not be done by the students. The results I have obtained with this kind of work have encouraged me to improve upon the system each semester. □

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mendations stated concisely at the end of each section. Overall, the Committee recommends a variety of specific changes largely oriented toward the educational process. Representatives of industry, academe, government, and engineering professional societies are urged to work together to develop the necessary initiatives.

In summary, the report presents carefully documented findings and useful recommendations intended to guide and inform the reader. It should be read by those concerned about engineering education and practice in the United States including engineering educators and administrators, government policymakers, and industrial leaders. □