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Who Will Take the Lead in Engineering Education?

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Engineering as well as engineering education have undergone tremendous changes since just before World War II. So much, in fact, have concepts changed that in any discussion of engineering one has to define first of all what the word engineering is to mean. For our purpose let us define engineering in very broad terms—as the professional pursuit of solutions to technological problems.

This definition in itself gives no hint of the causes for the changes that have taken place. In fact it describes quite adequately the engineering activities of the earlier part of this century and before. In those earlier days, however, the application of rather simple technical knowledge and of systematically collected data was so successful in bringing about spectacular advancements in the technological fields that the practicing engineer seldom was forced to go beyond this body of rather empirical information to achieve the solution of the technological problems which presented themselves. But the need and desire for even greater technological achievements increased, and by the middle 1930s it had become evident that the fundamental facts of physics and the techniques of mathematics were tremendously effective tools in the quest for solutions to technological problems. The results of the use of these tools were nothing less than spectacular —the achievement of space flight and lunar exploration being among the most impressive.

It is to the credit of the engineering schools that they quickly realized the impact that a more thorough training in mathematics and physics could have on the scope and effectiveness of engineering. The next decade saw a complete change in the curriculum of essentially every engineering school in the country. This resulted in a heavy emphasis on mathematics and physics as well as in a reorientation of the engineering subjects to a more mathematical or analytical approach. The beneficial effect of these changes became apparent very promptly. The graduates who had completed the revised curricula were in command of a broader technical base, which made them capable of attacking a greater variety of problems and of making more original contributions.

This success was, of course, noted with great satisfaction on the campuses, and the trend toward more mathematics and the more analytical approach was accelerated. As a consequence, in the minds of the students the mathematician and the theoretical physicist emerged as persons to be emulated, and quite frequently they were asked to become members of the engineering faculties. Beneficial as all of these developments were, the preoccupation with the basic sciences led the engineering schools to forget more and more the central purpose of engineering, which is to solve technological problems. The pursuit of mathematics and physics became an end in itself, and the fact that these disciplines were introduced primarily to give the engineers better tools was remembered only rarely. As a result, in many schools engineering lost much of its identity, and the subjects taught and the research pursued began to lose contact with the reality of the technological problems which the professional engineer must solve.

Many engineering schools as well as members of the profession are aware of these difficulties and are seriously concerned. They feel that the contact with actual problems should

The central purpose of engineering is to solve society's technological problems. Have our academic institutions lost sight of this fact in educating young engineers?

be reintroduced into engineering education and research. Such a reorientation, however, is no longer easy to accomplish. The trend toward the point of view of physics and mathematics has gone so far that in many engineering faculties there remain relatively few members who are oriented toward and stimulated by technical problems as they occur in society. Most of the faculty is likely to be oriented toward applied mathematics, and even the experimentalists are inclined to select problems on the basis of their intellectual appeal rather than for their relation to technological needs. More than that, the present trend is particularly difficult to redirect because the teaching of theoretical disciplines and the pursuit of pure research are particularly suitable for an academic atmosphere. They attract brilliant intellects to the faculty as well as to the student body—people with a thirst for exact knowledge and an aptitude for its elegant mathematical formulation but who are generally impatient with any restrictions imposed by nonscientific requirements.

But patience, a willingness to admit the influence of nontechnical factors, and an appreciation of the importance of detail are all characteristics of a professional man who serves the public, and among these are engineers as well as physicians and lawyers. For such professional men the principal goal is always the solution of the problem as presented by the public. The solution is to be accomplished in the most effective way, and this will often demand the application of a rather routine procedure which may not be intellectually challenging.

Educating these two types of personalities within the confines of the same campus presents a most difficult problem. The interest in many basic subjects will be common to both, and, therefore, a direct comparison of the performance of the various groups in these subjects is unavoidable, not only among the students but also at the faculty level. The mathematician, for example, is likely to be better in mathematics than the engineer, the physicist better in physics, and so on. In an attempt to meet this problem, the engineering divisions of most of the leading schools have attempted to recruit a faculty and a student body which, subject by subject, could successfully compete with the physicist and the mathematician and could at the same time preserve the professional engineering character. This lofty goal has generally not been accomplished, and the faculties in engineering consist more and more of persons who have but little interest in applied problems. The composition of the student body has undergone similar changes, and in those cases where admission is based on competitive performance in mathematics and physics, enrollment in engineering has simply faded away.

This method of admission—based on mathematics and physics performance—is a common one and therefore of basic importance. To visualize its effects more clearly let us imagine that the education of physicians rather than engineers is the subject of discussion. The comparable situation would then be one in which future chemists, physicians and biologists would be accepted into a common first year on the basis of uniform requirements. Chemistry and biology might well be considered subjects fundamental to all of these professions, and the acceptance criteria could plausibly be designed to accept only those who excel in biology and chemistry.

Let us then say that the admitting school finds that fewer and fewer students select medicine each year and that most of them prefer to become research biologists and chemists. The school would then be faced with the alternative of either abandoning its role in the education of future physicians or of admitting students to the study of medicine who demonstrably had poorer grades in biology and chemistry than their classmates who planned to major in these subjects.

In the discussion of these alternatives there probably would be those who would feel it unthinkable to allow anybody to become a physician who was not a top performer in the fundamental subjects. Others, however, might feel that the performance in these subjects was only a part of the qualifications needed by a physician and not a determining index of the person's future professional performance. They might argue that it would be shortsighted to jeopardize the school's role in educating future physicians because of an artificial academic requirement. By continuing to educate the best qualified of those who wish to become physicians, the school would be able not only to add to the number of badly needed physicians but would also be able to continue its function of improving and advancing medical education itself. In this latter aspect in particular a forward-looking university could render an outstanding national service.

The hypothetical plight of the medical school *does* describe the actual one of the engineering schools today. Moreover, engineering is in dire need of an academic rejuvenation, as the profession itself no longer has a clear identity and does not present a clear image to the public and the prospective students.

Those who differ from this point of view often argue that technological development in the United States has been phenomenal, and so apparently the training given to the graduates of American universities must have been most beneficial to growing industry. Therefore, it would seem important to continue emphasizing the basic disciplines of mathematics and physics even to the exclusion of more applied subjects.

A closer look at industry, however, will reveal two facts: First, a significant number of present-day technical personnel received their training when there was an emphasis on applications. Second, the lack of people who are well trained in the fundamentals but who also have an understanding of the more practical aspects is becoming very evident. The gap between those interested in science for its own sake and those responsible for producing actual devices and concrete solutions is becoming wider. Such a divergence does not augur well for the development of technology.

In a more philosophical vein one might even remark that it is a sign of decadence when pure science is pursued only as an artistic endeavor without a simultaneous, parallel effort to *apply* the scientific findings to further the goals of society. It is the function of the engineer in the technological field, as it is the function of the physician in the area of life sciences, to establish a bridge between the "pure" and the "applied." A healthy, forward-looking society will therefore see to it that there shall be strong professional groups to maintain this bridge.

It is not clear at present who will accept the challenge of preventing a gap from developing between the "pure" and the "applied" in the technological area. It appears that academic institutions are in the most favorable position to bring about the change in trend. In particular, an institution with a high reputation for its standards and scientific competence could exert a powerful influence. Such an institution would be relatively immune from criticism implying that the renewed interest in the "applied" might be the result of lack of success in the field of the "pure." Even a small pilot program carried out by such a school and designed for the education of professional engineers might be most influential and encourage schools all over the country to focus their attention on this problem.

Indeed, the trend toward the introduction of more "pure science" into the engineering curriculum was brought about in the late 1920s by the pioneering spirit of only a few schools. Maybe those same schools will again take the lead in charting the course for sound professional engineering education.