

LOOKING AHEAD IN PROFESSIONAL DEVELOPMENT

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In the early history of the industrial revolution the initial engineering developments were mechanical. It is true that chemical industry soon began to expand, in a sense paralleling the early developments in the mechanical field, but, relatively speaking, for a long period the chemical industries played a very minor part. About the middle of the last century they began to grow at an accelerated pace, and analysis of modern industry not only shows that the chemical phases of industry are today of major importance, but indicates that they are likely to increase considerably.

The magnitude of the development of chemical industry, and even more the character of its achievements, suggests that our educational institutions have little need to apologize for the quality of the chemical engineering training they have offered in the past. On the other hand, study of the industrial situation points to the conclusion that the demands which industry will make upon the engineer in the years immediately ahead will be far more severe and in many ways different in character from the responsibilities placed upon him in the past. It is the duty of our educational institutions carefully to appraise the situation and attempt to give today the training needed by the engineers of tomorrow. While these changes developing in industry are numerous, there are two of them which promise to be of outstanding significance.

The first of these fundamental changes in the character of industry is the sharply accelerated rate of development of processes and products. Someone has pointed out that the time-history of practically every new

idea in industry conforms to a given type of rate of growth curve. The birth of the idea is followed by a relatively long period during which progress is painfully slow. However, granting that the idea has sufficient merit, there finally comes a period of rapid expansion, which in turn is succeeded by a leveling off, corresponding to attainment of the ultimate place of the new development in the framework of industry. Thus, while the Bessemer converter was invented in 1856 and used on an increasing scale during the succeeding years, more than a quarter century later, in 1883, seventy per cent of all the pig iron produced in England was still puddled, but within the next five years this figure dropped to five per cent. In modern industrial developments the general shape of the rate of growth curve still remains the same, but the time axis is being greatly foreshortened. Industries develop, expand and mature far more rapidly than formerly. This accelerated pace of growth constitutes a most serious problem for the engineer. It reduces the time available for experimentation. It demands increased capacity for sound, fundamental analysis of highly complicated situations and far greater precision in quantitative design. Industry today demands in the engineer far higher technical capacity than a generation ago.

The second problem to which attention must be drawn is the rapidly increasing importance of the social factors in industrial work. It is no longer sufficient for the engineer to design and construct plants and develop processes which are efficient in utilization of materials, cheap in operation and high in quality of product. All this will still result in failure if the operations are of such character that labor will be dissatisfied, the distributing organization disgruntled, or consumer psychology outraged. Not only must the social problems of industry be met, but in the years immediately ahead these problems promise to be the most important and the most difficult which industry will face. Furthermore, they cannot possibly be solved by a personnel department un-

acquainted with the physical and technical facts. They can only be mastered by engineers possessing an adequate grasp of both the technical relationships and their social implications.

No one familiar with the curricula of our engineering schools or the performance of engineers in industry can feel that our present educational technique can meet the needs of the situation. Our engineering schools must develop an education program adequate for the future. This program must give the student a firmer mastery of engineering technique, a far deeper appreciation of the significance of the social relations in industry, and the power effectively to utilize this background of knowledge in the solution of practical problems.

One of the great engineers of the country has defined engineering as the art of the economic application of science to social purposes. The exact sciences underlying chemical engineering are mathematics, physics and chemistry, and the first problem in engineering education is grounding the student in them. Mathematics does not offer a serious problem, largely because the mathematicians have in recent years greatly increased the effectiveness of their methods of instruction. The engineering student comes to his professional work with a sound grasp of mathematical fundamentals and a reasonable ability to use mathematical technique in attacking the problems of the experimental sciences. Instruction in the latter, however, is unfortunately far less satisfactory.

The fields of physics and chemistry have expanded to such a degree that in too many cases instruction in these fundamental sciences has degenerated into an attempt to cover the ground, handing out a mass of information irrespective of the student's ability to master or even assimilate it. Any intellectual acceptance of the material presented cannot be due to appreciation of its background and hence of its meaning, but is a mere act of faith. Students thus trained have grandiose concepts but cloudy notions of their relations to the facts. Many

a graduate student, who will talk glibly of the third law of thermodynamics, is unable to give any idea of the nature of energy or the reasons for assuming its existence, or will define temperature as what the thermometer reads. One can appreciate fully the impossibility of giving a complete definition of these ultimate, fundamental concepts, and yet deplore the haziness and uncertainty of the average science student in dealing with them. Students thus trained are unfit for engineering work.

AIMS OF AN ENGINEERING EDUCATION

The difficulty lies in failure to appreciate fully the function of science instruction, at least for engineering students. That function is primarily one of mental discipline. Engineering students need first a knowledge of the fundamental facts. They need in addition not so much a knowledge of fundamental theories as an appreciation of the facts on which those theories are based and the logic by which they are deduced. This alone can give them an understanding of the scope and the limitations of those theories.

One of the difficulties of engineering work lies in the complexity of the situations which must be faced. The science departments can help greatly in the training of the engineer if they will devote a significant fraction of the instructional time available to those branches of science characterized by complicated factual relationships.

Our educational program in engineering is undoubtedly weakest with respect to the social sciences. How unfortunate it is that the student finds it so difficult to appreciate the importance of human relationships and the capacity to handle them effectively. My years of contact with industrial research demonstrate that success in the direction of research depends much more on the ability of the head of the laboratory to handle its human problems than on his technical brilliance or grasp.

To succeed, he must keep his staff not only happy

and contented but enthusiastic about their work. He must see that their spiritual energies are reserved for technical effort and are not taxed by economic worry, irritating personal contacts, or the depressing effects of an uncongenial intellectual atmosphere. Some of my own most careful professional work has failed because of my personal inability to secure the necessary cooperation from members of the organization through whom alone it could be brought to fruition. That my plans were technically sound was demonstrated later by other men more successful than I in overcoming the human difficulty.

Although they are in the curriculum, the social sciences require much more time than they are now accorded; mere classroom instruction will never accomplish results. The students must have practice in the art of human relationships. The time must come when every instructor in technical subjects, particularly in engineering branches, must consider it as much a part of his duty to direct and aid the student in understanding the technique of effective human contacts as to give instruction along purely technical lines. Not only must the pioneering work done at Purdue in this direction be adopted elsewhere, but it must be expanded and developed to far higher degrees of helpfulness to the student.

The instruction in engineering itself should have two primary functions: the first is the correlation and integration of the material presented in the individual sciences as a basis for the technique of using it in the attack on practical problems, and the second, the development of facility in professional work through practical experience in laboratory and plant. The first is primarily a problem of classroom instruction, while the second is the engineering equivalent of the medical internship.

INDUSTRIAL EXPERIENCE A NECESSITY

The furnishing of professional experience to the student is one of the weakest phases of engineering education. While laboratory instruction plays an important

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part in the engineering curriculum, it can never take the place of industrial experience. This is particularly true with regard to the matter of human relationships already emphasized. The day is coming when every engineering school of the first rank must furnish its students effective industrial contacts, in which they work under the direction of the faculty itself. Methods of this sort are, it is true, employed by a number of schools. Some of them have achieved considerable success but none of them have been able to impress themselves upon the profession with sufficient force to secure wide-spread adoption. Our engineering faculties can undertake few more promising tasks than the development of the methods of educational cooperation with industry.

There sometimes comes to a profession a period of outstanding opportunity for human service. Two thousand years ago the legal profession found such an opportunity in the development of Roman law. To the middle ages, priest and architect were able to render a unique service, the value of which has persisted long beyond the age that gave it birth. The last century has witnessed an extraordinary growth and recognition of the function of the physician, and the medical profession has taken advantage of it to make an unexcelled contribution to the development of a finer civilization. Now, the signs of the times point to the conclusion that the decades immediately ahead will offer the engineering profession potentialities for service of a quality and scope hitherto undreamed.