Science and engineering

BY HENRY C. BOURNE

When first we mean to build, we first survey the plot, then draw the model...

Shakespeare

Science and engineering have changed considerably in content and application since the time of William Shakespeare. However, a symbolic interpretation of the above quotation does not miss the mark by very much, although many of my good friends still naively insist, consciously or subconsciously, on a literal interpretation.

It is the purpose of this article to discuss some aspects of the meaning of modern science and engineering from the viewpoint of a university education and a career. Although this article is addressed chiefly to the potential science-engineering major, it will also be clear that the humanities major, student or professor, can no longer afford the luxury of only a rudimentary knowledge of modern science and engineering.

Don't Confuse The Two

First, let there be no mistake. Science and engineering are different. Considerable editorial forcing and some desperation was necessary before surrendering to the above title. Usually in articles with similar titles, the virtues of one are built on the neck of the other. We shall try to be fair although a little bias is sometimes interesting.

Traditionally, science is concerned with the gathering of information about nature and the physical world. The scientist is interested in the information for its own sake. He studies events in the physical world, either in his own laboratory if possible or in nature's laboratory if not, in order to determine the conditions and forces that are important to the event. His questions involve the fundamental ingredients necessary in order to make the event repeat.

When he is reasonably sure that all of the important inter-relationships have been ascertained, he constructs a theory. Facts are discovered and theory explains. If material objects are involved, it is for the sake of the theory and not theory for the sake of manipulating objects. Knowledge to the scientist is the power to predict the behavior of the physical world.

However, because the scientist is concerned with events in nature, it does not necessarily mean that he is materialistic. He is primarily concerned with ideas. The construction of a theory to explain the nature of light or of the atomic nucleus is just as creative and aesthetic an endeavor as the composition of a sonnet or the painting of a picture.

How Do They Differ?

How does the engineer differ from the scientist? It has been said that the engineer's problems are inexorable. He recognizes them as such and therefore lies his challenge. The engineer must solve the problem that society presents, and some solution he must have, if only approximate.

The physicist might study stress-strain relationships in an exceedingly simple shape tailored to his needs. The engineer is apt to be presented with a more practical but practically intractable shape. The chemist may study the construction of a few molecules under ideal laboratory conditions. The engineer is more apt to be faced with the design and construction of a process to produce economically large quantities of a given chemical in an environment of many unknown factors.

One is concerned with the detailed behavior of electrons in a very pure semiconductor. The other is concerned with the design of a device to control a kilowatt of power in a cubic centimeter of space. One is concerned with the behavior of particles in the Van Allen belt and the other is concerned with the design of the optimum system with which to take measurements required.

In the words of Gordon Brown, "Engineering is not merely knowing and being knowledgeable, like a walking encyclopedia; engineering is not merely analysis; engineering is not merely the capacity to get elegant solutions to nonexistent engineering problems; engineering is practicing the art of the organized forcing of technological change, and this is something very different."

At The Highest Levels

At its highest level, then, engineering is the creative translation of ideas into devices and systems for the benefit of mankind. At lower levels mankind becomes wife and children, employer, or self. In any case the key words, as with the scientist, are creative and ideas. Although the engineer deals with the physical world, it is the creative and imaginative application of knowledge which is the essence of good engineering. Hopefully the results of such application will be as useful as a learned tome on the economic history of Iceland 1910-1912.

The fairly long definitions above are probably worthwhile in view of the obvious confusion that exists not only in the minds of the public but specifically in the minds of students seeking an education and a career.

Certainly the confusion among students is evidenced by wide fluctuations in enrollments and numerous interdepartmental transfers. Certainly confusion in the public mind is evidenced by the blame attached to scientists when a satellite fails to orbit. The blame is sometimes justified because it has often been the childish engineering of scientists which caused the failure.

This situation in turn has been caused by the failure of universities to provide enough properly educated engineers. It is somewhat involved, John Dunning has warned that any engineer who forgets his unique metier in the envious desire to become a savant has abandoned a great profession and joined what has been called the oldest (Continued On Page 5)
The oldest profession

(Continued from Page 3) profession, and he will not prosper even in that.

If engineers do not aggressively claim the positions of leadership in our nuclear and space age—in which a mastery of the arts of systems design is needed, this nation will pay an intolerable price for amateur improvisation. With some imagination the warning may be paraphrased to apply to scientists.

However, neither warning should preclude the possibility that really first-rate men in both science and engineering are very often neither pure scientists nor pure engineers.

Alfred North Whitehead says that the justification for a university is that it preserves the connection between knowledge and the zest of life by uniting the young and the old in the imaginative consideration of learning. The university imparts information, but it imparts it imaginatively. At least, this is the function which it should perform for society.

A university which fails in this respect has no reason for existence. This atmosphere of excitement, arising from imaginative consideration, transforms knowledge.

Do They Belong?
The task of a university is to weld together imagination and experience. Although implied, we might also add that the university is further charged to be the leader in the creation of new knowledge. Does science and engineering belong on the university campus? This question is not asked very often of science these days, although many on the campus pay little attention to its existence.

Science has probably become nominally accepted since its cool reception in the 19th century English universities. The toleration of engineering is of more recent origin.

The Real Answers
In any case, the question is a valid one and the answer does not lie in the percentage of the national budget devoted to engineering problems nor to the fact that technology is a dominating factor in our time. The real answers lie somewhere in the definition of true science and engineering education, its meaning, purpose, and contribution to the creative understanding and the creative change of the environment in which we live.

Although volumes might be said, it is hoped that our conception of science, engineering, and the university are compatible. Certainly there is no more excuse for the scientist and engineer to have the most naive concepts of history or theology than it is for the historian or the writer to have the most naive concepts concerning the structure of the universe or how we are going to feed the world's population in forty years. On some university campuses, the only true liberal education is to be found in the College of Engineering.

A specific word to the young ladies is probably also in order. With less and less emphasis in engineering on field work and the test floor, and the increased emphasis given to the development of concepts and ideas, more women will find engineering as a proper outlet for their creative energies.

Women In Engineering
Research in the areas of systems engineering, applied mathematics, computer science, and solid-state and physical electronics present particularly attractive opportunities. We would like to welcome you not only because a bit of feminine pulchritude improves almost any situation but because we believe that a real and possibly unique contribution might result.

Much publicity has been given periodically first to the shortage and then a few years later to the oversupply of scientists and engineers. However, there will never be an oversupply of the type of scientist and engineer which is inherent in the description here and which we are concerned with educating.

Always An Undersupply
In fact, it is safe to say that there will always be a shortage of truly educated men. If you insist on becoming a scientist or engineer for more mundane reasons, then by all means begin your education during the peak of a so-called period of oversupply. Your timing will be just right.

Of all the scientists and engineers who have been educated, 90% are alive today. We live in an age when the advances in science and engineering can only be described in explosive terms. We are moving into new fields and problems present themselves in which past solutions are of little help. The education of scientists and engineers must change as rapidly.

The most discernable characteristics are new emphases on the humanities, on a broader background in several sciences, and on a more thorough foundation in mathematics—the language of science and engineering. For whatever reason you decide to become a scientist or an engineer, if we are successful in our educational endeavors, you will have visions and dream dreams.