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A re-examination of engineering education

Throughout modern history, one of the most written-about topics has been education, much of the writing done by the great philosophers and educators themselves. It is not the purpose of this chapter to enter the arena of the general philosophy of education, but some of this philosophy must be recognized in addressing the specific problem of engineering education and its capability to meet the needs of the profession and of society today.

H. G. Wells observed in *The Outline of History* in 1920, "Human history becomes more and more a race between education and catastrophe." With this in mind, we must reexamine our success in keeping ahead of the catastrophes as we see signs of them approaching.

Scientific and engineering education has enabled mankind to ward off catastrophes of many sorts. But in achieving this, we have created a world society that is heavily dependent on the resulting technology. A key element of this technology is a dependence on two very fundamental ingredients. One ingredient, limited by nature in its supply—which is rapidly diminishing—is fossil fuel. Another ingredient, limited by human resources and our economic system, is capital. As we see the possibility of a catastrophe resulting from the shortages of these basic commodities, we must look to education to gain a bit in the race to keep ahead.

An examination of the trends in engineering education reveals that perhaps there is good cause to initiate some improvements at this time. Engineering can be considered as a practical skill, i.e., the engineering practitioner generally applies the law of physics, channeled by guidelines developed through years of past experience, toward the end of producing a machine, structure, or other device to aid the productivity and comfort of man. This *channeling* effect has tended to steer engineering curricula into the path of *training*, rather than education. This trend has been strongly encouraged by demands of the marketplace that were a result of a total lack of comprehension or communication between the academic community and the business community. When the trend in engineering education was moving in the direction of producing theoreticians, the marketplace complained and put forth the cry for a more practical approach. This, it was felt, would make the engineering graduate more useful to the businessman. Without being recognized as such, the problem was one of pure versus applied science (Chapter 1); it was mistakenly identified as one of *education* versus *training*.

Educate rather than train!

The result is that the trend in engineering education has been to "train" engineers, rather than to educate them. Herein lies the essence of the problem!

In virtually any engineering curriculum, a certain amount of training is required. But, when the training becomes an end in itself, education has not been achieved and the curriculum has failed. The training is necessary to bring the student to the plateau from which the education can commence—it is only in this respect that education and training are synonymous. The training required preceding the process of total education in engineering is that portion of the curriculum that enables the educated engineer not only to understand and to make use of the fundamental sciences of

physics and mathematics, but also to have a comprehension of the current state of the art. The state of the art has grown and become so extensive during the middle half of the twentieth century that the problem of even fundamental training or skill development has consumed an overwhelming amount of the available time in the process of engineering education. As a result, the vast majority of curricula have lost sight of the goals of education and simply concentrate on training.

The observation is validated by a scan of not only the curricula of many undergraduate engineering schools but also the more popular textbooks. The trend has been to the "how-to" rather than the inquisitive "why-to."

The result of this has been the ability to develop, with the "how-to" state of the art knowledge, larger and more powerful automobiles, ever larger and more extensive building systems achieving the *n*th degree of the number of controlled zones and temperatures-humidity limitations, unprecedented electrical distribution networks, and countless other examples. With good fundamental training, successful design can be accomplished with a minimum of errors, but this also leads to very slow advancement in the state of the art. In some areas of the state of the art, advancement unfortunately ceases altogether where it is not pushed forward by immediate pressures from the marketplace—steam thermal systems, for example. Another disadvantage of a training-oriented curriculum is the failure of the practitioner to identify new parameters of design.

The leaders of engineering education should regroup, condense the period of training, and put more emphasis on education. The proposition is that *the ideal engineering education achieves adequate training, a rounded sampling of the humanities and related social sciences, and the stimulation of inquisitiveness and challenge*. It is the last of these that is needed so desperately if technology is to meet the challenge to ward off Wells' catastrophe.

To paraphrase Plato: "The direction in which education starts a society will determine its future."