Industry Needs SCIENTIFIC ENGINEERS NOT ENGINEERING SCIENTISTS*

ROBERT E. LENZ

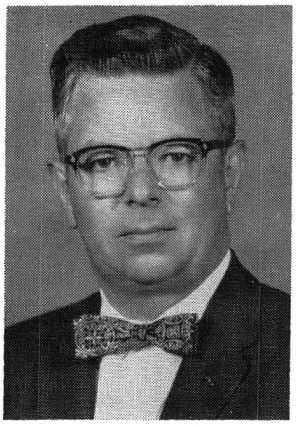
Director, Engineering Technology and Services
Monsanto Company
St. Louis, Missouri 63166

This talk presents a viewpoint of widening industry concern toward trends in chemical engineering education over the past five to seven years. The increasing emphasis on scientific fundamentals is producing broader students than the old "cookbook" courses did, and such students are better able to cope with the need to keep up to date. However, in those engineering schools where the science improvement is at the expense of teaching an engineering approach to engineering-type problems, the resulting graduate is some kind of pseudo-scientist with a degree labeled "Engineering." It will be increasingly difficult for industry to retrain him to make him an engineer. If he goes on to graduate school with the idea of teaching, he must find some exposure to engineering somehow, or he will become a teacher who turns out more "non engineers."

THE DEBATE between the academic community and industry on science versus engineering really heated up about the time of the Grinter Report. I have re-read the Grinter Report carefully and find myself in complete agreement with it. We had been teaching pragmatic engineering long after new tools had made it possible to use much more science. As industry sees the problem, some portions of the academic community over-reacted to the Grinter Report.

I hasten to comment that the overall result of the Grinter Report was good. Many schools upgraded and modernized their curricula and specific course content, so that their graduates had a more useful and more lasting education. However, a number of schools which were already science oriented took an equal or larger step in deleting most courses with engineering content and replacing them with still more science; some of them even labeled the degree "Engineering Science."

*Presented at the Annual Meeting of ASEE, June 19-22, 1967.



Robert E. Lenz is presently Director of Engineering Technology in the Central Engineering Department of Monsanto Company.

He is a graduate in Chemical Engineering from Washington University in St. Louis, and has served in various capacities in Research, Development, and Engineering for Monsanto over the last twenty-eight years.

Industry is not responsible for educating chemical engineers. However, we must use your "people" product to get our engineering job done. We cannot provide extensive formal training programs to remake science graduates into useful engineers capable of coping with the real world.

WE NOW HAVE THE CURRENT REPORT of the ASEE Goals Committee in which they propose using the MS as the first professional degree and trying to have 50% of those getting a BS go on to the MS. It would be irresponsible to suggest that more education is not desirable in a field of growing complexity such as engineering. It would also be irresponsible to suggest that students not be given an education with a more lasting character. We only need to be sure that, in educating the student for 1980, we turn him out capable of doing something useful in 1967 or 1968. And we need to be sure that the MS engineed is really getting *more* "engineering education."

I would like to make it clear that I am strongly in favor of graduate education in *engineering*. In this I am joined by other members of industry. However, our need for people with advanced degrees is not without limit. In Monsanto, for ex-

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ample, we have approximately 1000 chemical engineers. This includes 250 with MS degrees and 80 with PhD degrees. Of the 80 with the PhD, 45 are in research, 25 are in engineering and 10 are in all other fields. Of the 25 in engineering, 12 work in areas under my direction. These are men who are doing excellent work in developing new engineering tools and methods. However, these 12 were not easy to come by; they are the "net" of nearly 25 PhD chemical engineers who started work in this area; the other 13 have transferred to research or gone back to the universities.

It want to emphasize that this engineering work is in the area of advanced technology. It does require the best people we can get. It is not connected with cranking out repetitive designs of heat exchangers. Even so, when we interview PhD candidates, we find that many of them are not attracted to this type of work because it is not science oriented, and our records show that only about half of those who are attracted originally will stick with the engineering assignment. The exposure to real engineering problems comes as a severe shock to many of them.

QUITE A FEW OF THE PEOPLE who start with us and don't stick return to the academic world to take up their research where they left off and to start training students. If they are unwilling to do engineering work in the real world, I wonder if we should encourage them to teach and influence students who are apt to come out with the same "non-engineering" attitude. James Fulton recently published an article entitled "Where Have the Engineering Colleges Gone?" I would like to share one paragraph of his paper with you:

> "This science-emphasis trend of engineering colleges is not only detrimental to the engineering state-of-the-art, but it also misdirects the students. The students in engineering courses are generally faced by a teacher who is conducting science research and whose patterns of thought are more strongly directed toward analysis than synthesis, whose mental habits are inductive rather than deductive. Their teacher's allegiance leans toward science and away from engineering, and his approach to the course material is shifted accordingly. As a result, engineering students leave college well prepared in theory and scientific principles but lacking the ability to put this knowledge to use."

In all of this I have assumed that we might have a common understanding of the word "engineering." There have been many attempts to define it; I am willing to walk a short distance on this shaky ground. I consider engineering to be the application of science to the optimum solution of multi-valued problems. In most cases, this means the *economic* optimum. A less formal definition says that an engineer can make for 25¢ what anyone can make for $1. Science, on the other hand, concerns itself principally with facts, most of which are the correct answers to single-valued problems, and with systems to organize these facts. I disagree strongly with the Goals Committee in defining engineering as "liberal science." Liberal arts graduates approach problems by extensive verbal analysis; engineers get things done.

Many PhD candidates in chemical engineering are, in reality, training to become research scientists. Now, we have lots of use for research scientists—including those in the field of engineering—but they will be used to do research; and *somebody* has to do the engineering. And if we are going to have our engineering done well, some of these engineers should be the top talent obtainable from our engineering schools. Five years ago, when this group met at Boulder, Mott Souders gave a talk entitled "What Industry Expects of the Chemical Engineer." One paragraph of that talk is particularly appropriate here:

> "We need both scientists and engineers, but we don't expect a scientist when we hire an engineer. The engineer differs from the scientist in interests, motivation, goals and accomplishments. The scientist strives to know, the engineer to produce. Understanding is the goal of the scientist, utilization the goal of the engineer. The accomplishments of the scientist are based on analysis, those of the engineer on synthesis. If the education of the chemical engineer shifts to science, even engineering science, at the sacrifice of the arts of design, industry will use the future "chemical engineer" as a scientist, but will have to look elsewhere for process engineers."

It would be relatively easy to destroy the meaning of the word "engineer" by perverting it to mean some kind of scientist—just by repeating it often

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enough. Look what the communist world has done to the word "democracy" by using it so consistently in the sense of their "people's democracy."

THE CURRENT SITUATION is not solely the result of over-reaction to the Grinter Report. The federal government has made vast sums available to graduate students, mostly on a "no hardship" basis. In doing so, they have established the policies for funding research and for the type of research which will get these funds. For many years we have heard people express the fear that "federal support of education will eventually mean federal control of education." Some of this is now evident in the enforcement of federal policies below the college level in the southern states. Much of it is evident in the graduate research programs in our chemical engineering schools. The schools look for professors who can bring in these funds. These men then pass their same interests on to their graduate students.

This is close to the main message which I want to bring to you. We do not have a bad-versus-good, black-versus-white situation of what is science and what is engineering. We have a set of attitudes which are developed by students in their four years of close association with their professors, and which are much reinforced by their closer association for those who go to graduate school. It is what *you* do and what *you* say that counts in developing the students attitude toward engineering work. Fortunately, a large number of chemical engineering departments turn out excellent engineers at all levels. These are the people we try to hire—at all levels—to do our engineering work at all levels. Unfortunately, there are a number of schools who take the scarce promising raw material and turn out class after class of "non-engineers."

We have learned from bitter experience to be quite selective in the schools from which we will interview PhD candidates for engineering work. We are even learning to be selective about which professors have guided the students. I hope this will not be required at the MS level very soon. Of course, there is no doubt that a proper MS experience will produce a much better engineer, since he may have as much as 100% additional professional course work than he had for the BS. However, we should consider the real possibility that some MS graduates may be poorer *engineers* than they were at the BS level, because of the reinforcement of their training in science.

I WOULD LIKE TO EMPHASIZE that there is still a real opportunity in industry for the top quality BS man, if we could convince him that his work experience might be just as valuable as additional academic training. In the past such men rose rapidly to positions of real responsibility in engineering management and broad company management; they were the prime source of vice presidents. Their real interest in economic optima was easily transferable to the business world. This potential is much less available to the man at any level whose real interest is strictly science.

The engineer with the best education in science, channeled toward the solution of engineering problems, will make the maximum immediate contribution and will have the education that is easiest to update. For an engineer, the key words are "channeled toward the solution of engineering problems."

The AIChE has been concerned about this problem for at least five years. Here are some examples of that concern as expressed by recent Presidents of the Institute:

Bob Marshall's Presidential Address:
Science Ain't Everything

Ben Franklin's editorial in CEP:
The Challenge of Design

Stu Churchill's article in CEP on
The Preliminary Goals Report

Ted Burtis's talk entitled:
Industry and Education

Max Peters's talk at the ASEE Summer School on the same subject.

Through various types of activities, I come into continued contact with the top engineering people in most of the major chemical and petroleum companies. I can assure you that most of them share the concern I have expressed here today.

For engineering work, we need scientific engineers, not engineering scientists.