WHAT DOES DU PONT LOOK FOR IN ITS CHEMICAL ENGINEERS

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While the program implies that I will be "speaking for Du Pont, " I am sure you realize that no one can really "speak-for" an organization on a subject of this sort. In preparing the talk I have had discussions with many people covering a wide range of interests and responsibilities and found no strong disagreement with the points of view expressed here. However, I am sure that had any one of these people prepared the paper, it would differ in many ways. I quickly found that every person polled had a different opinion, in fact, I soon despaired of producing an "opinion" useful to you. Most seemed to feel that the current graduate was not so bad but certainly could be better. There was some thought but little, if any, firm evidence that today's graduate may not be as broadly useful as those of some years ago, though the opposite view was also met. Eventually I came around to asking "What does Du Pont look for in its Chemical Engineers"? It is to this specific question that I will now address myself.

In what follows I will first attempt to give you a brief picture of what Du Pont looks for in its chemical engineers. This will, in effect, attempt to describe a product we want to obtain, and it will be your product I will be talking about. Next I will raise some questions regarding your responsibility for certain important aspects in the education of chemical engineers. Finally, I will make a few suggestions looking toward more emphasis on some of these aspects.

To provide background let us look at Slide 1 which shows, for 1961, the distribution of technically trained people in Du Pont among a number of disciplines.

DISTRIBUTION OF TECHNICALLY TRAINED PEOPLE IN DU PONT-1961

	%
CHEMICAL ENGINEERS	28
CIVIL "	4
ELECTRICAL "	5
INDUSTRIAL "	4
MECHANICAL "	16
OTHER "	4
CHEMISTS "	31
OTHER SCIENCES	8
	100

(TECHNICALLY TRAINED MAKE UP 14% OF ALL EMPLOYEES)

You will note that people trained as chemical engineers make up 28% of all technical employees, while mechanical engineers and chemists are the other major groups. Slide 2 shows the distribution of chemical engineers in a few areas of Du Pont effort.

DISTRIBUTION OF CHEMICAL ENGRS IN SOME AREAS OF DU PONT (1961) AS PERCENT OF TECHNICALLY TRAINED

	%
COMPANY AS A WHOLE	28
TOP ADMINISTRATION	42
GENERAL AND ASSISTANT GENERAL MANAGERS	38
SALES AND SALES DEVELOPMENT	29
CENTRAL ENGINEERING DEPT.	23

I give these figures only to show that the chemical engineer is found in many areas of Du Pont activity, including management. Other areas such as production and research activities were not surveyed but I would not expect the distribution there to depart significantly from the company average. These figures, unfortunately, can no more than hint at the destinies in Du Pont for present graduates. They do suggest, however, that the long-time usefulness of your graduates will depend much more upon their abilities to cope with problems which require integration of people, science, engineering, and economics than upon their abilities, however excellent, to design equipment or plan the technical aspects of a research study. I do not suggest that excellence in chemical engineering design, or a sound basis in thermodynamics or an adequate background in solid state physics, as example, are no longer important. I am suggesting that such excellence is not enough. Indeed, it has little utility until it has been applied. Application is so important that the man who has only a little knowledge but who has learned to employ it effectively can become the most useful; i.e., the best paid, man in the organization. As time goes on such a man develops a wide ranging knowledge because part of his effectiveness depends upon recognizing areas where his knowledge is inadequate and then doing something about it. In other words he grows. We want men who will grow and continue to grow throughout their whole lifetimes, men with insatiable curiosities, men who meet the broad problems of our industry and recognize them for what they are, exciting, challenging, and rewarding.

Remember, now, that our problems involve a combination of people, science, engineering, and economics. This is true whether the area be management, research, sales, product development, or plant design. These problems do not necessarily require the attention of chemical engineers, and there are many cases where people without chemical engineering training have become exceedingly able as solvers of chemical industry problems. Is there any unique value, then, in a chemical engineering education? I believe there is. A chemical engineer entering the chemical industry will usually start with reasonably well defined assignments not too far removed from his classroom experience. He is expected to handle them effectively. It is most important that his initial efforts be successful. Sound training in chemical engineering including as much experience in handling problems as is practical in his schooling are the best preparation he can have. At this point he can have a distinct advantage over, for instance, a man trained in mechanical engineering, but also can be at a disadvantage if the latter has learned much more effectively to employ his knowledge. Assuming equal effectiveness the chemical engineer will start with an advantage and should be able to grow more rapidly provided only that he has as good an aptitude and has received through his living and educational experiences the same sort of incentives to grow. But note that effectiveness in the use of knowledge can more than take the place of specialization.

Perhaps from all this you begin to see some picture of what we want in chemical engineers. First we want men well prepared to handle defined problems -- problems not too far removed from the kind met with at school but problems which may involve many phases of scientific knowledge or experimental approach. "Well prepared" includes undertaking with confidence of success relatively simple scientific or engineering application work in fields foreign to their academic experience. In the end we want men who will grow rapidly till they can handle quickly and effectively not only the multidiscipline problems so common in the chemical industry but also the multiaspect problems -- people, science, engineering, and economics -- which are common to all industry.

How your current product "stacks-up" against these wants I am not prepared to say. Many of the people with whom this paper was discussed are concerned that the current emphasis on "engineering science" will take emphasis away from the application of science. Science is of value to us only as it is applied. The schools have a real responsibility for turning out graduates who are as well prepared as possible to help us solve our immediate technical problems; they have a much larger responsibility, I feel, for turning out people who will grow; people with insatiable curiosity, people with a vision of exciting, challenging and rewarding work ahead.

I suspect this statement of our "wants" while possibly interesting may not be very helpful to you. Let me be more specific. When we employ a chemical engineer (or any person for that matter), we want a man who will solve our problems, a producer, an effective worker. We tend to take for granted the items of his formal education and focus on those aspects that determine whether he can and will use his formal training effectively. Can he write, talk, listen? Does he possess initiative? Curiosity? Confidence? Reliability? We suspect that the effectiveness of chemical engineers in doing our work is more dependent on the experience they have had in using their knowledge than on the knowledge itself. It may be that the problem work required in the "chemical engineering" courses provides "experience" to a greater degree than is found in other engineering disciplines, and that this experience is a factor behind the chemical engineers' reputation for versatility. If so what an opportunity there should be to turn out a much improved strain of chemical engineers simply by ensuring still better experience during school years in the application of knowledge!

Let me be very emphatic concerning problems. I am not confining myself to problems involved in equipment selection design, fabrication or operation. We want men who will also tackle effectively cost analyses, product development, patent prosecution or sales effort -- to name a few areas -- when problems in these areas require their attention; but we do not expect trained experts in all these and other fields. We want people who will employ effectively what they know; and people who expect to acquire new knowledge as their work requires it.

Warren K. Lewis has stated the objective of chemical engineering training in somewhat this manner "to so prepare a man that, when faced by a new and unusual situation whether technical, social, or economic, he will handle it with confidence and effectiveness." If we accept such a statement for our guide, we are led to two questions, (1) "What knowledge and experiences does a man require in order that he will tackle the new and unusual situations of the future with confidence and effectiveness?" and then, (2) "What part should the school play in ensuring that the student acquires both the essential knowledge and experiences"?

No one will disagree that a person must have a reasonable grasp of all cogent factors before he can take competent action; I wonder if it is as self-evident that he must also have some confidence of success before he will take action. Such confidence, for most of us I dare say, comes only as the result of previous successful achievements. If you will grant me this conclusion, we are led to three secondary objectives for chemical engineering education which back up the main objective, these are:

1. To help the student acquire as sound as possible a grasp of the sciences, the humanities, and the engineering disciplines. It is of equal importance to stimulate him to continue his self-education.
2. To provide experience in meeting successfully new and unusual experiences and situations which may require information from many disciplines.
3. To make the student aware that problems in engineering (and in life) seldom have single answers; what we seek is the best answer, even though we may have to settle for less.

Under item (1), the student acquires the basic knowledge that makes it possible for him to handle the practical problems; with this knowledge he can tackle the unusual problem if he will. With the background of experience gained under item (2) the student acquires the confidence he must have before he will tackle the unusual problem. Finally with some experience under item (3) the student becomes aware that most practical problems involve people, science, engineering, and economics. Am I correct in believing that current teaching emphasizes item (1) and almost excludes from active consideration items (2) and (3)? Coming back to item (1) -- here is the field of curricula. What subject matter must the student be exposed to; how can a proper choice be made of the most essential bits from the mass of new and old material? Once chosen there are time-tested teaching methods which, however, tend to rely heavily or entirely on illustrative problems with a single correct answer. Let me return later to the problems of choice of material and of the one correct answer.

What kind of experiences are needed (item 2) to develop confidence leading to action? For this, I suppose, personal success in handling analogous problems is the necessary experience. I recall the first church fund drive in which I participated. This I would have avoided almost by any means but in the situation I could not do so and finally with actual dread I approached the first call. You know what happened, it was a pleasant, not an unpleasant, experience. That one experience opened the door to me for all kinds of personal contacts which I otherwise might have hesitated to make. By the same token, the student who has successfully employed energy and material balances to solve problems ranging from the efficiency of a coal fired boiler plant to the heat of reaction in a fluidized bed converter, should now be confident that the same tools can be usefully employed in any area where there is a transfer of mass and energy. As I have indicated before, experience in this specific area may be back of the chemical engineers' willingness to tackle problems outside the scope of his direct experience. Under item (2), I would suggest that, among other things, a student should meet a few problems where he must supply missing data; others where there is unnecessary information; and still others where the actual problem turns out, after analyzing the information, to be different than that originally stated. Moreover the student should have practice in thinking his way through problems to obtain approximate answers quickly -- to size the problem before spending time to get the exact solution. I feel that ability and initiative in thinking through problems in a quantitative way is of sufficient importance both for developing confidence, for stimulating curiosity, and for increasing effectiveness that no one should be allowed to graduate in chemical engineering without formally demonstrating such ability. Note, however, that facility at mental mathematics is essential. Do you ask for proof that a student has achieved even this facility?

Tom Sherwood, some years ago, published a paper in the ASEE Journal on the subject "Should Engineering Schools Teach Engineering." He was talking about item (3). It seems unlikely, to me, that many of the illustrative problems used in teaching can be of the open ended sort because the staff effort required to handle them would be too great. There should, however, be enough such examples and with the proper emphasis so that the student appreciates he is dealing with problems more nearly like those to be met with in industry. I believe this can be done if the need is recognized and the effort made. I would expect that implementation of items (2) and (3) would not require more courses, but would be handled by the way in which existing courses are taught. Note that AIChE's Chemical Engineering contest problem has at times constituted a step in this direction.

Let me recapitulate what we think we want in chemical engineers.

We in the chemical industry see continual increase in the variety as well as the depth of the problems our chemical engineers must face, with the new and unusual the daily fare for many. We need men who have a sound basing in the sciences and mathematics, a reasonable acquaintance with technology, enough experience in applying their knowledge to problems requiring bits from several disciplines including economics so that they will know it can be done, some acquaintance with the open-ended problem -- the one requiring a "best" answer, a well developed curiosity, -- and the ability to communicate. I have emphasized the importance of "people, science, engineering, and economics." We all work for some one and others work for us. The importance of science, engineering and economics are, no doubt, readily apparent to the student. He cannot, however, possibly understand the importance of people until he has had organizational experience in working for another or in directing others. While nothing can take the place of actual experience, he should be aware of the problem, particularly of the problem of communication, to the extent that he will expect it and look for it. Perhaps you could use every report or examination paper as a specific example of a problem in communications. Individual conferences with student could appraise the students' deficiencies and emphasize communications difficulties.

Now let me conclude with a few thoughts regarding curriculum -- the material largely contained in item (1) of the slide. This may be "old stuff." If so, I apologize in advance. One may organize the material a student will encounter into the categories of:

Tools - mathematics; physical and chemical laws; communication which includes spelling, writing, speaking, listening, languages; etc.

Knowledge - the sciences, technologies -- organized information in general

Information- largely how things are done, mechanical and electrical devices, pipe-fitting, maching, equipment generally

Experience - knowledge derive from one's own action.

The tools are the student's most basic asset. They are used to manipulate knowledge -- to put it to use. Choice of the tool subjects required is relatively easy and good methods of teaching are available with the single exception of communication which seldom, if ever, is adequately covered.

Knowledge covers an enormous span and here there is real trouble deciding what areas should and can be included. Minimum coverage of important areas should include emphasis on general principles with enough application to specific problems so that the student will be confident that, with a little study, he can handle practical problems. Many important areas cannot be covered even to this extent but contact should be carried to the point that the student will remember he has heard of it, and will carry away the impression that this area too can be mastered by study if need be. In considering the "what to cover" and "how to cover it," the prime consideration should be "what does the student need to establish his confidence that he can find his way around in this field."

Information covers a far wider field than knowledge. Here, I feel, we have much to learn regarding choice of material and teaching methods. For example, there are many physical tools which the student may well need to use in later life but which time is too short for him to experience with his own hands. Orsat analysis, surveying tools and methods, pipefitting, lathe operation, operation of a distilling column, excavating equipment, pile drivers; or information retrieval systems, and computers. Here is needed only some kind of mental index that tells him yes, I saw that, I am sure I can find the information. For example -- when I was a student at M.I.T., all chemical engineers had a year of machine tool lab; today that laboratory does not exist. I feel that both approaches missed the point. One doesnot need a year's lab work on machine tools to convey an understanding of what can be done -- yet no engineers' education can be considered complete without some such understanding. Here a carefully prepared movie series in perhaps three, one-hour periods, could, I believe, give a broadly, useful understanding of the whole field and leave in the student an adequate feeling of confidence that he understand the essential features of the technology. Application of this principle to many existing courses could, I would hope, reduce the amount of effort required and at the same time provide a very much broadened base of information.

As I am sure you are aware most everything I have said could be applied to other engineering disciplines equally well. This would be fine -- it could provide Du Pont with better engineers in every field.

To Summarize:

We look for men, including chemical engineers, who will apply their knowledge effectively to the wide range of unusual, multidiscipline problems that they will be exposed to in the chemical industry; problems that cannot possibly be anticipated during their school years. We want men who will continue to grow in breadth and depth. We want men with insatiable curiosity.

We suspect that confidence in his ability to handle unusual problems, confidence based upon experience in actually handling unusual problems, is necessary before the man can be confident of ultimate success. Without such confidence it is unlikely that effective action will result. The schools have a high degree of responsibility for providing such experience.

We suggest that in choosing what to teach and how to teach it the guiding principle should be "how much need the student know and how much practice must he have to gain a soundly based confidence that, given time, he can master the unusual problem." We would hope, as a result of such an approach, that curricula could be simplified but at the same time be greatly strengthened.

You may probably feel that the suggestions just made are naive and impractical -- perhaps they are. They are offered only in the hope that somehow you can find the ways to give us engineers -- chemical engineers -- who both can and will tackle still more effectively the broad range of unusual, exciting, challenging and rewarding problems which characterize the chemical industry. Such men will have curiosity of a high order and will grow in usefulness to themselves and to industry throughout their lifetimes.

In closing, I would like to leave two different but related questions in your minds. (1) Do you make a real attempt to bring to your students a feeling for their responsibilities as professional men and as citizens? Perhaps personal example would be the best teacher here. How many of your staff take active parts in professional society, civic, or a church work? (2) Are you looking to the secondary schools for long-range help in your own curricula? Is there not a good chance that some share of the time spent by college freshmen could be covered in high school? Are you doing something about it?