THE CHEMICAL ENGINEERING CURRICULUM

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If it is to be completely meaningful, an analysis of chemical engineering curricula should properly start with a consideration of the objective sought, and only then examine the means by which the objective is achieved. A suitable objective for chemical engineering education is suggested by the AIChE's official definition of chemical engineering as the profession which is concerned with processes and equipment in which material is treated to effect a change in state, energy content, or composition.

It follows that the chemical engineering student must learn the pertinent characteristics of "change" if he is to be successful in terms of this definition. These characteristics might be broken down as follows:

1) What changes. Here we are concerned with the states and properties of systems, thermodynamically speaking. This area of subject matter is generally covered in physical chemistry or in a first course in chemical engineering.

2) How much changes. The first law of thermodynamics is pertinent at this point, but most schools teach this aspect of change in a course devoted to materials and energy balances or stoichiometry. Three credit hours are devoted to this topic in the average curriculum.

3) Which way and (4) how far will the change go. These two considerations are associated with second law thermodynamics and the concept of equilibrium. On the average, approximately 5 credit hours are allocated to the subject of thermodynamics, but it should be noted that some of this time is used to review first law principles.

5) How fast the change occurs. The rate concept is commonly treated within the unit operations area or, in the case of chemical processes, in a separate course in kinetics. Since the average curriculum devotes only one credit to reaction kinetics, it must be presumed that most of the instruction pertaining to the rate concept comes as part of the unit operations sequence.

The foregoing might be referred to as the theoretical aspects of change. It remains to make practical application of these aspects in seeking answers to the following:

6) How the change can be effected. The study of the unit operations provides needed background in this area, and the survey showed an average of eight credit hours to be devoted to unit operations theory and an additional four hours to be devoted to laboratory work. It should perhaps be noted that no attempt was made to determine the extent to which the transport phenomena approach is being used.

7) How to measure and control the rate and extent of change. Only one credit hour is allocated to process instrumentation in the average curriculum, but it is certain that this topic is also treated as part of the unit operations sequence at many schools.

8) Finally, how much does it cost. This brings us to the economic question as it applies to design. Engineering economics is presumably taught as an integral part of the design sequence at most schools, since only 23 per cent report a separate course in this area. On the average, four credit hours are devoted to chemical engineering design.

In passing, it can be noted that the average curriculum contains seven credit hours of instruction which do not clearly fall into any of the above categories. For the most part these credits pertain to courses in technology or unit processes, and to research projects or electives.

The unit operations, being concerned with the application of knowledge, skill and judgment to the design of equipment which will be practical, safe, and economical, have long been considered to be the strong point of chemical engineering. Generally speaking, either of two approaches may be used: One may write the pertinent differential rate equation and integrate it to relate equipment size or processing time to the change to be accomplished; or, one may use the equilibrium stage approach.

Neither of these design methods is particularly difficult to comprehend, and it is somewhat surprising that they do not receive at least introductory attention earlier in the curriculum. The basic aspects of equilibrium stage calculations, for example, are rather straightforward extensions of mass and energy balance applications. Why should such calculations not be introduced when the latter topics are treated at the sophomore level?

An even stronger case might be made for introducing the generalized rate concept early in the curriculum. Certainly it is at least as important as the balance concept, and a preliminary exposure to the idea of driving forces should be an ideal preparation for the subsequent consideration of equilibrium in thermodynamics. Furthermore, the general relationship among rate, driving force, and resistance can be readily grasped at the sophomore level.

With such an introduction, instruction in the unit operations could be largely devoted to a consideration of the various rate coefficients and the environmental factors which affect them. The importance of economic factors and sound engineering judgment would also receive emphasis.

The foregoing comments are not presented so much as a recommendation -- although the author's personal experience has shown such an approach to be highly effective -- as they are to stimulate thought with respect to curriculum planning and the optimum arrangement of subject matter within the curriculum. Note that the sessions planned for the present meeting will be concerned with only approximately one-third of the total curriculum -- and only one seventh if we disregard the half-day session on chemistry.

This is as it should be for a meeting which is subject-matter oriented rather than concerned with teaching methods and curriculum planning. Yet someone must plan curricula, and new ideas and fresh approaches in this area are no less important than are new areas of subject matter within the curriculum.

The results of the survey here presented would appear to suggest that there has been little change in the chemical engineering curriculum in the past five years. We all know that this is not the case, for there have been significant changes within a relatively stable curricular framework. The lamentable fact is that such changes are all too frequently not reported to groups such as this so that they can be tried elsewhere, perhaps adopted, and, most important, perhaps built upon to achieve even more satisfactory results.

Such is the responsibility with which I wish to charge you in conclusion; Let us continually analyze our curricula, course content, arrangement of subject matter, etc., in terms of what we are trying to accomplish, how we are going about it, and how effective our efforts are. Let us experiment to identify new and more effective ways of achieving our objective. And, finally, let us report the results of both our analyses and our experiments.