WHAT WILL WE REMOVE FROM THE CURRICULUM TO MAKE ROOM FOR X?*

Bite the Bullet—Throw Out Obsolete Material

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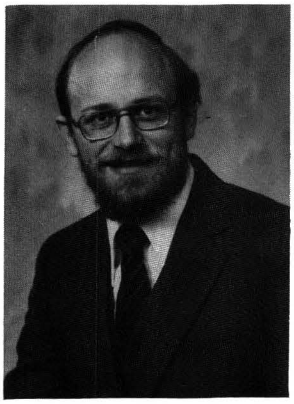
THE QUESTION IS: how do we get new material into the chemical engineering curriculum? The Septenary Committee on Chemical Engineering Education for the Future, sponsored by the Department of Chemical Engineering at the University of Texas [3] has done the profession a service by pointing out the need for change in the education of chemical engineers. This committee also suggested, in general terms, some ways that this can be done. In this paper I will first review some methods of making room for new material in the curriculum while retaining a four-year program. Then the question of which material has become obsolete will be considered in more detail. Finally, specific material in the area of separations which I think should be deleted or changed will be delineated.



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MAKING ROOM IN THE CURRICULUM

A variety of methods to make room for new material were mentioned by the Septenary Committee [3]. These will be briefly reviewed and expanded with some specific examples.

Avoid Duplication

Teach material once, and then use the material in other courses. There is an advantage to teaching material more than once and from different viewpoints; however, this seems to be a less effective use of the limited available time than covering important new areas. Plan the key course in the subject to explore the theory, the philosophy, and some applications of the subject. Then in later courses expect the students to use the material to solve problems. Perhaps the best example of teaching material more than once is thermodynamics. At many schools thermodynamics is taught in physical chemistry, in physics, and in chemical engineering. Reducing some of this duplication would make more time available for other subjects.

Purposely do not cover some of the material students will have to know for laboratory and design projects. One of the objectives of the laboratory or design project would be to require students to ferret out information on their own. This search for information and then using it could be guided at first and totally without help later.

Do less teaching of multiple ways to do the same thing. For example, learning ten different calculation methods for multicomponent distillation is probably not the optimum use of time.

*Presented at the AIChE annual meeting, Miami Beach, FL on November 4, 1986.

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Use Problems and Examples

Many students (and practicing engineers) have trouble generalizing. They cannot see that many of the methods they know can be applied in new areas. Practice in generalizing can often be done through examples and homework problems without teaching a lot of new material. For example, Michaelis-Menton kinetics for enzymes is Langmuir-Hinshelwood kinetics by another name. If Langmuir-Hinshelwood kinetics is covered in a course, Michaelis-Menton kinetics can easily be introduced either as an example or as a homework problem. This method for introducing new material can also help the student broaden his search for a job. For instance, the production of ultrapure water is important in electronics and can be done with standard chemical engineering unit operations. A problem on production of ultrapure water in an electronics plant would be a good homework assignment in a unit operations, separations, or design course.

REMOVE OR REPLACE OBSOLETE MATERIAL

Everyone agrees that obsolete material should be removed. The difficulty is in deciding what *is* obsolete. The modern practice of chemical engineering is becoming more and more computer and programmable calculator (which I will shorten to computer) oriented. Thus, we should teach in a *computer friendly form.* Teach material in a form which is easy to use with the computer. This will encourage students to use computers and prepare them for using the computer in their careers. A small fraction of our students will use the computer whenever possible and do not need any encouragement. Another small fraction of students treat the computer like it has AIDS—these students are hard to reach. The biggest fraction of students, however, use the computer when it is convenient, and we should encourage them by teaching material which is computer friendly. Computers *can* be over-stressed; however, I believe this is rarely done.

Using the desire to teach computer friendly material as a guide, I have selected the following material as prime candidates for removal from the curriculum.

- **Complex graphical calculation methods. The Ponchon-Savarit method is obsolete. The vast majority of students never learn the method well enough to use it to think, and the method does not appear to be used in industry. The McCabe-Thiele method is not obsolete since it is very useful as a tool to think about distillation problems even if a computer is used for the design.**
- **Mechanical drawing. The computer is doing drawing and graphing jobs. However, typing has replaced this as a useful skill. Pre-engineering students should be encouraged to take typing in high school.**
- **Graphical (count the squares) integration. Teach some of the simple numerical methods.**
- **Graphical correlations. An excellent way to show the fit of the correlation to data, but graphs are not computer friendly. Teach the equation form of the correlations in addition to the graphs.**
- **Nomographs.**
- **Trial-and-error methods devised for hand calculations.**
- **Flow sheets for obsolete processes. This can be a problem in design courses and requires industrial contacts to avoid.**

Why is it difficult to throw out material which is now dated? First, it may be difficult to identify which material is obsolete. Second, the material is probably included in all the books we teach from, and replacing it will be quite time-consuming. (This point is discussed in detail in the next section.) All our lectures and problems use the old material; again, replacing it will be time-consuming. Student access to computers may be limited (however, their access to calculators is not). Most professors learned to use computers when they were batch systems. Many professors have not adapted to modern computer work station engineering and are not prepared to teach computer friendly material. Finally, we learned this material and are very comfortable with it, and thus on some level feel that all chemical engineers should learn the same material.

SPECIFIC NON-COMPUTER FRIENDLY MATERIAL IN SEPARATIONS

I am not qualified to evaluate the entire chemical engineering curriculum. I do feel qualified to evaluate the areas of separations and the physical properties required to solve separations problems. I have extensively reviewed a number of modern (1980 and later) books which cover separations, and have identified where these books are teaching material in non-computer friendly ways. What I have found is that these books universally cover a lot of material in ways which are not computer friendly. Unfortunately, this means that most courses will be taught the same way.

Physical Properties

We will start with the physical properties required for many separation calculations. Almost universally

Continued on page 81.

WHAT WILL WE REMOVE

Continued from page 73.

the physical properties are listed in graphical correlations, nomographs or tables. This strongly encourages the student to do hand calculations.

1. K values. Simple determination of K values is done with the dePriester charts. Usually these monographs are presented without any equations in correlation form [4, 8, 9, 10]. The presentation of both the dePriester charts plus correlations in equation form would be preferable. Faust *et al* [4], present equations in terms of temperature at different selected pressures, and do not present the dePriester charts.

More detailed analysis of K values often includes description of various computer friendly methods [4, 6, 7, 9], but some books present the convergence pressure charts which are not computer friendly [5, 9].

2. Physical properties: viscosity, specific heat and enthalpies. Both viscosity [1, 5, 8, 9, 10] and specific heat [1, 8, 9, 10] use a nomograph form which is difficult to use and provides no physical insight. Correlations in equation form are readily available [*e.g.* 11] but have not permeated into the separations literature. The steam tables remain in tabular form. Accurate equations to correlate this data would be very useful to encourage computer problem solving.

Separation Method Calculations

There are several examples of presentations of non-computer friendly material in teaching separations. This list is not inclusive.

1. Ponchon-Savarit Diagrams. As was mentioned earlier I think that the Ponchon-Savarit analysis of distillation is now obsolete. McCabe *et al* [8], and Perry and Green [9] apparently agree since this material was removed from the latest editions. However, it is difficult to obtain agreement on what is obsolete. Other authors [1, 2, 4, 5, 6, 10] apparently disagree since they have included this material. The use of the Ponchon-Savarit or triangular diagram in extraction calculations appears to me to be more justified. This method is included in most books which discuss extraction.

2. Graphical solution of Kremser or Colburn equations. Back in slide rule days these equations could be difficult to solve and graphical plots of the solutions were justified. With the ready availability of powerful calculators this justification is no longer valid. The continued use of these graphs in many books [1, 4, 5, 6, 9, 10] is a good indication of the inertia involved in producing chemical engineering textbooks.

3. Gilliland Correlation. The Gilliland correlation is a useful short-cut technique which was originally done in graphical form, but has also been correlated by equations. Inclusion of both a figure to show the fit to data and an equation appears to be the best way to present this material. This has been done in Henley and Seader [4], King [6] and Perry and Green [9]. Only the graphical correlation is presented in other books [5, 7, 8].

4. Graphical integration. Graphical or numerical integration is required for batch distillation and for the HTU-NTU analysis of packed columns. Methods such as the trapezoidal rule which is easy to computerize are preferred over count-the-squares graphical integration. The trapezoidal rule is used by Faust *et al.* [2], Hines and Maddox [5], and McCabe *et al* [8], although Faust *et al* show a count-the-squares graphical integration in batch distillation. Only count-the-squares type of graphical integration are shown in other books [4, 7]. King [6] and Treybal [10] state that graphical integration is done, but do not illustrate it; thus, the instructor can do what he wishes.

5. Design correlations. A number of graphical design correlations are routinely used in separations. For example, the two O'Connell correlations are often used to estimate the overall efficiencies of distillation and absorption columns. This is invariably shown graphically [4, 5, 6, 7, 9]. Unfortunately, I am not aware of an equation form of this correlation although generating such an equation is straight-forward. As a second example, the Sherwood correlation (often as modified by Eckert) is used for both flooding and pressure drop of packed columns. Equations for the pressure drop curves are available for different packings [9], but an equation for the flooding curve does not appear to be available. Most books which cover this material give the graph only without any equations [1, 4, 5, 6, 7, 8]. Many other examples in this area could be shown.

Obviously, book authors could be much more careful to try and cover material in computer friendly forms. This would greatly aid professors in teaching the material in computer friendly forms. Unfortunately, if the goal is to make room for other material, only large changes, such as not teaching the Ponchon-Savarit analysis, have a significant impact. The other changes will update the course, but they don't make room for other material.

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