UNDERGRADUATE EDUCATION
Where Do We Go From Here?

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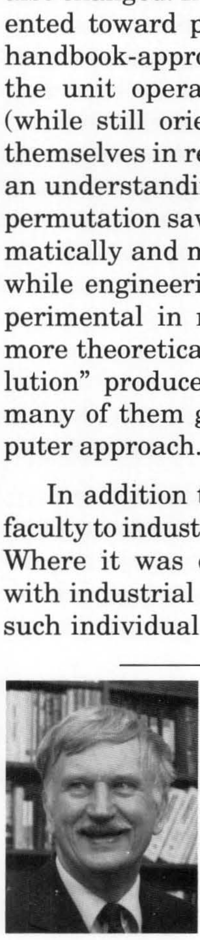
Chemical engineering undergraduate education has undergone many changes and transformations over the years. It has moved from a curriculum best described as industrial chemistry through the unit-operations approach, to an emphasis on engineering sciences (*i.e.*, transport phenomena) with greatly increased mathematical sophistication, and ultimately to a heavy infusion of computer-based methods and techniques.

The nature and background of the faculty has also changed. Initially, the typical professor was oriented toward practice and to what some called a handbook-approach to teaching. Later, however, as the unit operations approach took hold, faculty (while still oriented to practice) began to involve themselves in research that was designed to provide an understanding of complex phenomena. The next permutation saw faculty becoming both more mathematically and more scientifically oriented. Further, while engineering research had been mainly experimental in nature, it now began to take on a more theoretical slant. Finally, the "computer revolution" produced a new breed of professors, with many of them geared almost exclusively to a computer approach.

In addition to the above, the relationship of the faculty to industrial practice has also greatly changed. Where it was once common to encounter faculty with industrial experience, there are now far fewer such individuals, particularly among junior professors. It is not uncommon at some institutions to find many, if not all, of the departmental core courses taught by faculty whose experiences are wholly confined to academia.



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The changing curriculum and changing faculty have obviously had a great impact on chemical engineering education (in particular, on undergraduate education). There is no question that today's baccalaureate graduates are considerably different from their predecessors of twenty, ten, or even five years ago. Today's chemical engineering graduates are sharp, they are highly-sophisticated mathematically, and they are quite proficient with respect to the computer.

All would seem to be well. However, when engineers in industry (including new hires) are asked to evaluate today's undergraduate chemical engineering education, they raise a number of questions. For example, newly-minted engineers complain about a lack of "practical information" in their training. The serious thing about this charge is that it even comes from students who have graduated from institutions which strongly emphasize practice rather than theory. Complaints of older engineers range from an inability of new hires to carry out well-known procedures to their lack of even a rudimentary understanding of equipment.

At this point, a number of different opinions would be elicited. One type of response would be that there is no problem and that all is well. Others, however, would probably recommend a massive reorganization of chemical engineering education in order to cure any and all perceived problems.

Actually, both camps are correct in their evaluation. Massive changes in curriculum, courses, *etc.*, are not needed; what *is* needed is a change in the way the material is presented. We must move from an over-balance and dependence on theory, mathe-

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matics, and the computer, to a new approach that not only recognizes and maintains those gains but also clearly links them to engineering practice.

How do we do this? We do it by changing the style and philosophy of teaching our undergraduate courses. At the risk of oversimplification, the following points should be considered:

- **Continue to teach fundamentals, but emphasize the first principles even more strongly.**
- **Make the greatest possible use of phenomenological approaches.**
- **Clearly delineate the progression, use, and relationships between theoretical, semi-empirical, and empirical approaches.**
- **Emphasize practice by continually interlinking theory to actual or real situations. Do this quantitatively; if unable to do so, use qualitative and/or anectodal examples.**
- **Build on first principles by using homework or examination problems that emphasize applications in different, new, or novel areas or applications (*i.e.*, enable the graduate to move into new areas of technology).**
- **Put mathematics into its proper perspective (*i.e.*, useful and important, but not the be-all or end-all).**
- **Use the computer, but emphasize that it is a means, not an end, and that garbage in gives garbage out.**
- **Work into each course the concepts of process and equipment.**
- **Emphasize innovation, creativity, and ingenuity, remembering that an engineer is a "person who carries through an enterprise by skillful or artful contrivance."**

A response to the preceding might be that we already do these things in academia, so why bother? It should be evident that even if we are doing them, as academics we are falling short and must therefore emphasize them even more strongly.

Another comment might be that these are admittably worthwhile objectives, but how can they be implemented? A possible scheme for implementation in chemical engineering departments would be to:

- **Commit to a teaching philosophy that emphasizes the preceding points as well as others that accomplish the same goals.**
- **Take advantage of the valuable resource of faculty with industrial experience to track the undergraduate core courses so that theory and practice can be effectively interlinked.**
- **Utilize, as well, those faculty members who specialize in experimental research so that the aspects of equipment and processes can be emphasized.**
- **Develop good rapport with industry so that examples, guest lecturers, *etc.*, can be used to enrich core courses.**
- **Build on science and mathematics, but clearly emphasize the fact that engineering is different.**
- **Evaluate all of the preceding by contacts and discussions with recent graduates and more mature practicing engineers.**
- **Keep the undergraduate curriculum dynamic, recognizing that static situations produce deterioration.**

Hopefully, this paper will stimulate discussion and more detailed consideration of undergraduate education in chemical engineering. This in itself would be a rewarding and beneficial exercise. ❐

ChE **book review**

VISCOUS FLOWS: THE PRACTICAL USE OF THEORY

by Stuart Churchill
Butterworths, 80 Montvale Avenue , Stoneham, MA 02180; $52.95, 602 pages (1988)

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Professor Churchill has produced a textbook aimed at the student with prior background in fluid dynamics, although he states that it has been used with "surprising success" as a first course for undergraduates when the material is presented at a slower pace and with some deletion of detail. My own impression is that this book could indeed be used in a junior-level fluids course, but that its success would depend to a great degree on the skill of the teacher in choosing the topics to be included, and in supplementing the material of the text with ample classroom discussion so as to provide a broader context in which fluid dynamics is seen as an essential element of chemical process engineering. In the hands of a teacher whose main focus would be on the derivation of solutions to various fluid dynamics problems, the use of this text would be less successful in providing

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