Random Thoughts . . .

THE ALUMNI SPEAK

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Several years ago I taught five chemical engineering courses in successive semesters to a cohort of students, beginning with the introductory course on material and energy balances (the stoichiometry course, CHE 205). I consistently used a variety of nontraditional instructional methods, most notably cooperative learning (assignments carried out by teams of three or four students with various measures being taken to assure individual accountability), and compared various learning outcomes for the students in these classes with the same outcomes for a group of traditionally-taught students. A description of the instructional methods and a summary of the results may be found in the *Journal of Engineering Education*.*

In the fall of 1999, I sent a questionnaire to the 72 students in the study who graduated in chemical engineering, inviting them to reflect on their undergraduate education—what they liked and disliked, what helped prepare them for their current careers, and what advice they would have for today's beginning chemical engineering students. I eventually heard back from 50 of them, a respectable 69% return. Of the respondents—most of whom graduated in 1994 or 1995—33 (66%) were still involved in engineering and the remaining 17 were in different fields. Eleven (22%) had earned advanced professional degrees—four PhDs in chemical engineering, four medical degrees, and three law degrees. Those still in engineering included four process engineers, four environmental engineers, three each in engineering management, product development, production engineering, research and development, and quality assurance, nine in other engineering jobs, and one in graduate school. Those who left engineering included four computer systems managers or programmers, four physicians, three attorneys, two full-time homemakers, one executive recruiter, one human-resources manager, one machine operator, and one doctoral candidate in science and technology.

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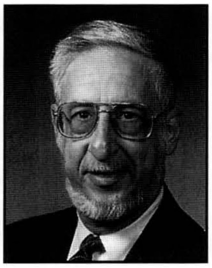

The respondents were asked to list the features of their undergraduate education that had proved to be most valuable in their career development. Items mentioned and the number of respondents citing them included

- *The problem-solving and time-management skills they acquired by working on so many long and difficult assignments (25)*
- *A variety of benefits gained from working in teams on homework (23)*
- *What they learned in the stoichiometry course (8)*
- *The broad knowledge base they acquired in the curriculum (6)*
- *Troubleshooting skills (3)*
- *Knowledge of statistics (3)*

No other item was mentioned by more than two individuals.

*(1) R.M. Felder, "A Longitudinal Study of Engineering Student Performance and Retention. IV. Instructional Methods and Student Responses to Them," *J. Engr. Education,* **84**(4), 361-367 (1995);
(2) R.M. Felder, G.N. Felder, and E.J. Dietz, "A Longitudinal Study of Engineering Student Performance and Retention. V. Comparisons with Traditionally-Taught Students," *J. Engr. Education,* **87**(4), 469-480 (1998)

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Specific courses besides stoichiometry that were cited more than once included thermodynamics (2), mass transfer and separation processes (2), freshman chemistry (2), and mathematics (2).

In their open comments, almost every respondent spoke positively about group work, mentioning its learning benefits and/or the interactions with classmates that it fostered. For example, *"I formed very close relationships with my group members that remain today. I realized that I wasn't alone in struggling with new concepts and could garner support and help from teammates."* and *"Being forced to meet other students through required groupwork. . .kept me in the course long enough to develop the skills and self-confidence necessary to continue on in the CHE curriculum."* No one said anything negative about group work, although two respondents indicated that they disliked it initially and only later came to see its benefits.

Other features of the curriculum that got favorable citations from several students included

- The laboratory courses *("I always enjoyed the labs because you put to use all those hours of class time.")*
- In-class exercises *("The structure of the classes helped me to learn more by having active involvement in the class instead of the typical 'I lecture, you take notes and shut up' approach.")*
- Connections with chemical engineering practice *("Not only did Prof. ... try to provide real life examples, but we also had visitors from industry come in and explain how they used their college backgrounds in their fields. This information helped me to decide which industry was most appealing and best suited to my interests.")*

Common recommendations for beginning chemical engineering students were

- Pay attention to the stoichiometry course (10) *("CHE 205 is the most important course you can take—the first step in any engineering calculation is a material/energy balance.")*
- Study and work hard (9) *("Prepare yourself for a new way of thinking, 'cause this ain't high school, and you're not going to be able to coast. Work hard early and you won't have to play catch-up.")*
- Stick with it (8) *("Don't get discouraged if you don't do so well at first. People do get better as the curriculum progresses. (I did.)")*
- Take teamwork seriously (7) *("Get to know as many people in the class as soon as you can—this will get you through the homework and the tests. Teamwork is a way of life out in the real world. It will frequently be a major factor in how you are 'tested' at work.")*

Two students suggested that students struggling to make it through most of their chemical engineering courses might reconsider their choice of a career path. One put it this way: *"Any time you feel stubbornness getting you through some trial, you should consider why you need it. I fully believe that anybody will make passing marks in any subject area that truly interests him or her. If, on the other hand, you find the problems and concepts difficult, do not take this as a sign of intellectual failing, but rather as a sign of disinterest."*

Several points about the survey responses submitted by these alumni are particularly noteworthy. I was struck by the fact that only four respondents were involved in process engineering and three in engineering research and development, which is to say that fewer than one out of six were working in the areas addressed by essentially all of the core chemical engineering courses beyond the stoichiometry course. Many cited the value of the stoichiometry course in their academic and/or professional careers, stressing its importance in the advice they gave to beginning chemical engineering students, while no other core chemical engineering course was cited by more than two respondents. In contrast, almost every respondent noted the benefits of the problem-solving and teamwork skills they had acquired in the curriculum and many mentioned the value of their exposures to engineering practice. (The term "real world" came up fairly often.)

These observations suggest to me that the specific content of our core courses beyond stoichiometry may be less important than we tend to believe—much less important than the industrial relevance of what we teach and the extent to which we help our students develop problem-solving, communication, and teamwork skills. When we review and revise our curricula, we might do well to concentrate on addressing modern engineering practice beyond process design and analysis and on explicitly facilitating critical skill development, and worry less about how many advanced unit operations and differential equation solution techniques we can shoehorn into the courses. Besides helping our students, this change in focus won't do us a bit of harm at the next ABET visit. ❒

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