WHY ARE YOU TEACHING *THAT?*

Richard M. Felder

When I think back on all the crap I learned in high school, it's a wonder I can think at all.

(Paul Simon)

My undergraduate experience wasn't as bad as that, but it left a lot to be desired. If I try to think of things they taught me that I ever needed to know after the final exam, I can't come up with much. I needed some math and material and energy balances, of course—everyone needs them—but little else. I sat through a lot of long derivations I still see no purpose for, a bunch of empirical correlations I doubt anyone has used in the last 50 years, and enough useless information about the chemical process industry to fill thousands of Trivial Pursuit cards without repeating a single fact. At one point I could have told you all about the process used to extract whale oil from blubber. Seriously.

How about the courses you teach? If you went to some of your alumni and asked them what in their college education turned out to be really useful in their careers, what do you suppose they'd tell you?

I did that a few years ago. I surveyed 72 chemical engineering alumni I had taught, asking them to reflect on their college experience and tell me what about it was helpful in preparing them for their current careers, and 50 of them responded.[1] Practically none of the curriculum content made their lists. Skills, yes, especially the problem-solving skills they learned from those endless assignments (25) and the communication and time management skills they got from team projects (23). Only one specific course was nominated by more than two people, however—material and energy balances, naturally (8). As far as the students were concerned, the content of those 4–5 years worth of math and science and engineering courses was mostly irrelevant to their careers.

If you look through everything you're teaching and consider how useful it might ever be to the students, you'll certainly find some "need-to-know" material—things all graduates in your field should know and instructors in subsequent courses will assume they know. You'll also find material that makes you wonder "Why am I teaching this stuff?" It may have been important once but it's now obsolete, or maybe it's one of those "nice-to-know" topics you enjoy teaching but not one in a hundred students is ever likely to use. If you're like most of us and have more jammed into your course than you can comfortably cover, consider cutting down on some of that superfluous material. Here are some candidates for cutting:

- ***Simple facts that require memorization but not conceptual understanding.*** *(The blubber conversion process comes to mind.) If the facts are important, list them in a study guide, tell the students they need to memorize them, and don't spend valuable class time droning through them. If they're not important, drop them.*
- ***Simple formula substitutions.*** *Once students have seen an example of a volume being calculated from a temperature and pressure using the ideal gas equation, they don't need to see six more examples just like it.*
- ***Obsolete information.*** *There's little point in spending time on processes that no longer exist, methods no longer used, and (with some exceptions) approximate ways to solve analytical problems that can now easily be solved exactly.*

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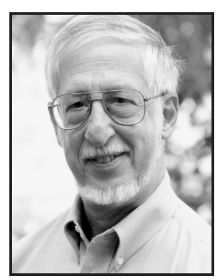

- ***Long mathematical derivations.*** *If you're teaching, say, an introductory fluid dynamics course, there is little value in spending three class sessions trudging through a detailed derivation of the Navier-Stokes equations. You'll probably never ask the students to do anything like that, and few could do it if you asked. The only ones likely to ever need to do it are those who go on to graduate school, and that's where they'll learn it.*

So, let's suppose you find some expendable content in your course. What should you replace it with that might better serve the needs of your students?

The list is long, but what's not on it is replacing Content A with Content B. Most course content outside the basics has a limited shelf life, and the accelerating pace of development in technology makes it shorter every year. Your goal should not be to keep the curriculum up to date with current knowledge—you'll never win that battle. Rather, try to prepare your students for what they will have to do to succeed in their careers—understand fundamental concepts at a deep level, think creatively and critically and globally, and gain new knowledge and skills in multiple disciplines without the help of professors and lectures and grades.

Do we know how to equip students with those abilities? Not completely, but we know a lot.[3] Just to give you a taste, here are some exercises you can use in class activities and assignments to promote development of critical skills in any technical course.

- ***ConcepTests.*** *State the result of an observation or an experimental measurement and give a multiple-choice question about it that requires understanding a concept or principle. Students generally enter responses using some form of clicker technology, and the instructor uses the distribution of responses to identify and correct student misconceptions. The* AIChE Concept Warehouse[4] *contains more than 2,000 ConcepTests that cover most of the core chemical engineering curriculum.*

- ***Troubleshooting exercises.*** *After students complete a calculation of some system variable, tell them to suppose the value was measured and the result was 40% lower than what they calculated. Then give them one, two, or all three of these tasks: (i) brainstorm possible reasons for the difference between the calculated and measured values; (ii) list the three most likely reasons and explain why you selected them; (iii) formulate a plan to determine which, if any, of your proposed reasons is the actual one.*

- ***Ill-defined problems.*** *Give problems that are overspecified, underspecified, or unclearly stated, and have the students identify what's wrong and reformulate the problem statements. Teaching students to do that sort of thing helps prepare them for most of the problems they will encounter in their careers and also addresses the frequently forgotten first two components of ABET Outcome 3e (identify, formulate, and solve engineering problems).*

- ***Creative and critical thinking exercises.*** *Assign questions and problems that help students learn to think outside the box (creative thinking) and to make judgments and choices based on solid evidence and logic (critical thinking). Many kinds of exercises provide practice in those skills,[5] including explaining unexpected results in measurements and calculations, making up potential exam problems, selecting from alternative methods, models, or designs and justifying the selection, and critiquing project reports and articles.*

You don't have to do all of those things in your course, and you probably shouldn't even try. If you just do a few of them, though, and some of your colleagues do the same in their courses, you'll produce graduates who are far better equipped for their future workplaces than most traditionally taught students are. As for the nice-to-know content you cleared out to make way for the skill development, trust me—no one will ever miss it.

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