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WHO NEEDS THESE HEADACHES? REFLECTIONS ON TEACHING FIRST-YEAR ENGINEERING STUDENTS

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In the period from Fall 1995 to Spring 1997 I coordinated and taught in an experimental freshman engineering curriculum called **IMPEC** (Integrated Mathematics, Physics, Engineering, and Chemistry Curriculum). One of my jobs was to teach a one-credit fall course designed to

- serve the traditional orientation functions of the freshman engineering course
- provide real-world motivation and context for the science and mathematics fundamentals taught in the core freshman courses
- provide training in critical success skills.

I started my teaching career in 1969 and by 1995 I thought I knew a few things about how to teach, but I found that teaching first-semester college students offered several new challenges. While I didn't exactly have to scrap the teaching principles and methods that had worked for me before, I had to add some new strategies to my bag of tricks. For what it may be worth, here are some of the things I wish I had known in August 1995. Some of them come from my own experience and many come from watching and conversing with my colleague Phil Dail, who taught the IMPEC chemistry course. Phil is a former North Carolina high school science teacher of the year who has also taught freshman chemistry to several thousand students and is my nominee for the best teacher of first-year college students I have ever seen or heard of.

Principle 1: Entering first-semester college students were high school students three months earlier.

Many high school students are mature, thoughtful, and industrious, but those are probably not the first three adjectives that come to mind if you are trying to describe the species collectively. A sizeable percentage of high school students lack the sound judgment, sense of responsibility, and work ethic needed to do well in a curriculum as demanding as engineering, and they're not likely to magically acquire these things in the summer between high school and college. A great deal of the well-publicized first-year attrition from engineering undoubtedly stems from the assumption that freshmen should be capable of functioning like seniors from the word go. That's a really bad assumption.

Principle 2: Success skills have never been taught to most first-year students, but they (the skills and the students) are teachable.

This observation of course does not come as news to anyone familiar with the gospel according to Landis. I knew enough of the gospel to know that *Studying Engineering* was the only text to use for the course I was about to teach, but there's nothing like first-hand experience to bring home the reality of something you've only read about. Why should we assume that we have to teach freshmen the product rule for differentiation or Kirchoff's law but somehow they are

perfectly capable of learning by themselves to manage ridiculous time demands or form themselves into high performance teams? That's another terrible assumption. If we want our students to learn a complex procedure or master a complex skill, we need to provide them with some guidance.

Fortunately, all skills--including the ones we want our students to acquire--can be developed and improved through practice and feedback. If we want students to differentiate complex trigonometric functions, for example, we outline how it is done, give them examples, give them practice problems, correct and grade their efforts, give them more practice problems, and finally test them on their ability to solve similar problems. Not surprisingly, most of them end up knowing how to do it. If we did the same thing to facilitate the development of study, communication, teamwork, or time management skills, the result would be identical: most of the students would master those skills to an extent that most faculty members wouldn't imagine possible. Without structured training and practice, however, forget widespread mastery of high-level skills. What we'll get is instead what we've been getting and complaining about for years in that familiar faculty lounge grumbling about the lousy quality of today's students.

Principle 3: The principles of good teaching are also applicable to teaching freshmen

As I noted at the beginning, the things I had learned in 26 years of teaching non-freshmen engineering students still applied in the first-year course. For example,

- Write instructional objectives that cover all the skills you want the students to develop and design your class lessons, assignments, and tests to reflect your objectives.
- Model the strategies and skills you want your students to develop.
- Maximize active, experiential, problem-based learning; minimize lecturing.
- Use cooperative (team-based) learning extensively, both in and out of class.
- Don't make speed a major factor on tests.
- Positively reinforce successful performance.

Principle 4: The first semester of college is not necessarily one of life's happiest times

Unless they went to a gifted and talented magnet school, most first-year engineering students were at or near the top of their high school classes and breezed through their courses hardly ever needing to crack a book. It comes as a severe shock when they discover that their classes are filled with people who are as bright or even brighter than they are and that papers that would have earned automatic A's and commendations several months earlier now come back covered with red marks and critical comments. They are stunned to learn that unless they really study and do lots of homework outside class--even (gasp) on evenings and weekends--they get tests back with grades they never even knew existed.

About a month into the fall semester Phil Dail asked the IMPEC students to rate their current stress levels on a scale from 1 (no stress at all) to 10 (unbearable stress) and invited them to explain their ratings. The average rating for the class was between 7 and 8. Most of the students

were anxious about grades and many were suffering crises of confidence in their abilities for the reasons just described. That was just the beginning, though. They were also in desperation over homesickness, roommate problems, health problems, financial problems, recent or impending relationship breakups, severe parental pressures to succeed, too much or too little social life, recent or impending parental divorces, sick or dying family members, and intense peer pressure to get involved with alcohol or drugs. When I read those papers I was amazed that so many of the students were able to get out of bed and face the day every morning, let alone concentrate on academics. I reminded myself of this situation periodically throughout the semester. It helped me cut them some slack when they didn't always meet my expectations about attending and participating in class, completing assignments, and studying for tests.

Principle 5: Attitude is three-quarters of the battle

What makes Phil my nominee for best first-year college instructor I've ever seen is much more than his deep understanding of chemistry and his ability to transmit that understanding. Watching him in action for two minutes makes three things abundantly clear to his students and to anyone else fortunate enough to observe him. First, he enjoys and cares deeply about what he is teaching and he is absolutely passionate in his desire for his students to share his enjoyment and appreciation. Second, he believes with every fiber of his being that all of them are capable of succeeding. Third he will take it as a personal failure if any of them fail for any reason. His students see this and they respond. He pushes them to understand chemistry, experimental science in general, the connections between theory and experimentation, and the need for clear communication of results, at a far deeper level than their counterparts in the standard curriculum are ever required to reach. He teases, cajoles, challenges, hurls mock threats...and when they succeed he almost falls over himself in his eagerness to praise them. With few exceptions, his students get where he wants them to go.

Phil's enthusiasm is contagious and inspired the rest of us on the IMPEC faculty to try to emulate him. It worked. In the end, the students turned in some outstanding written reports on challenging engineering design projects, gave oral presentations of their work that would put most of what goes on at professional conferences to shame, and significantly outscored control groups on a variety of performance and self-confidence measures.

Teaching freshmen can be exasperating, and it's easy to conclude that it isn't worth the effort to overcome the obstacles they put in the way of their own learning and growth. The main thing I learned in two years of teaching them is that it is worth the effort. If you're sufficiently patient, thick-skinned, and positive, and if you maintain unshakable faith in their ability to succeed despite themselves, they will reward you by December with understanding and skills you would not have believed possible in September.