Editorial: Undergraduate Education

ON JULY 1, I retired from my university position. As I approached retirement, I began thinking about the academic environments that had consumed the major portion of my 41-year professional life. As I reflected upon my experiences, my primary attention was focused on my first love, undergraduate engineering education, and several questions came to mind. The purpose of this editorial is to raise these same questions in your mind, give you a few of my thoughts, and, hopefully, get you thinking about the future of undergraduate education.

Is technology really important in undergraduate education?

I firmly believe that technology is "not important" in the education of undergraduates! Now, I know that this statement will be considered heresy by many readers, but think about the reality of your undergraduate education.

My undergraduate education took place in the late 1950s. The electronics technology of the day involved vacuum tubes. I did not see a transistor for the first time until I was a Graduate Teaching Assistant assigned to teach the laboratory for an elective course on transistor theory. And my first question was, Where are the heater connections? (You members of the "younger generation" will probably not appreciate the humor in that statement.) The computer language of the day was FORTRAN 2.

My point is that the technology that served as the playing field for my undergraduate education in electronic engineering did not sustain me through my professional career. (And, I doubt that the technology to which you were exposed as an undergraduate will sustain you throughout your professional career.) In fact, I was essentially technologically obsolete the day that I received my B.E.E. degree. So what did sustain me throughout my professional career?

What is it that made my engineering undergraduate education different from the undergraduate education of other disciplines?

The answer to this question is also the answer to the previous question. I was sustained throughout my professional career by an undergraduate education that taught me how to think and organize my thoughts, how to analyze problems in a critical manner, how to design creative solutions to open-ended problems, and how to learn on my own. I was sustained because my undergraduate education required that I rigorously pursue each problem to completion with personal discipline. (No! I was not subjected to an ABET-mandated group capstone design project where major goals were to learn how to "get along with people" and "work well with others." I was required instead to learn and accomplish every aspect of each major project on my own so that, when I was asked to work in a group, I could accomplish any assigned task without having to "coattail" on the skills of another member of my group.)

While the technology of the day was the context in which these characteristics were taught, the technology was not the primary focus. I believe that the unique skills and characteristics instilled in me during my undergraduate experience is what made my undergraduate education different than other undergraduate programs and of more value to me.

My concern today is why we, as faculty, let this important aspect of the undergraduate engineering education experience fade from being a major emphasis in undergraduate engineering education.

What is the major current problem with undergraduate electrical engineering education?

It is my belief that we, as academicians, have become curriculum reactionaries rather than curriculum visionaries. We react to changes in our discipline as opposed to anticipating the changes or introducing revolutionary change. I consider this situation to be the major current problem in undergraduate electrical engineering education.

Think about the current education we provide undergraduate electrical engineers. We start with calculus, calculus-based physics, and chemistry, and proceed from circuits, logic, and networks through electronics, controls, electromagnetics, and machinery to "technology courses." But are we really teaching the correct subjects for the future practitioners in our discipline? For example, when was the last time that your curriculum dropped a "core course" in favor of a different "core course?" (I am not talking about dropping a core course so that another technology course can be added at the junior or senior level.)

Carrying this question one step further: How often is the chemistry subject content in your curriculum used in later courses? As we look to the future in robotics, communications, and computers, would not a course in biology serve as a better foundation for our discipline than would chemistry? Would not a major restructuring of the physics sequence to provide a broader emphasis on optics better serve the purposes of the education process for graduates that have a 40-year professional career ahead of them? (I will get to the upper-division courses in just a moment.) In general, we, within the discipline, are not asking the hard questions about curriculum content. Instead, we are waiting to see how our field develops and then, after the fact, changing our undergraduate education subject content. (The MIT faculty is to be congratulated for its willingness to forge new frontiers with a biology requirement in the undergraduate program.)

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Academicians should be visionaries—not reactionaries! We are too slow in making the changes needed in order to provide our graduates with the foundation required to meet the future needs of society.

Why are we such fanatical worshipers of the subdisciplines of electrical engineering?

Let me continue my last point with a focus on the structure of our undergraduate programs after the core courses. We teach specialized courses in circuits, logic theory, networks, electronics, electromagnetics, machinery, controls, power systems, and communications. Yet, few real-world problems confronting our graduates can be pigeonholed into such neat compartments. The real-world problems that engineers must solve normally transcend two or more subdisciplines of electrical engineering and often cover multiple disciplines of engineering. So, why do we feel the need to structure our curriculum with a year's sequence in individual subdisciplinary subject areas? Why not start teaching our students courses that cross subdisciplines and require that problems that cross subdiscipline boundaries and even the boundaries of the disciplines of engineering be solved in the course? For example, think about the number of perspectives from which we teach static and dynamic principles in our curriculum: physics, mechanics, circuits, electronics, electromagnetics, and controls. Why are the perspectives so limited? Will all static and dynamic problems be so well structured? I think not!

I suggest that we are not properly preparing our undergraduates for the practice of electrical engineering by failing to populate our undergraduate programs with a healthy dose of problems that cross subdisciplines and disciplines. A single capstone group-design project does not get the job done.

Why, in the United States, does our discipline accept the requirement that an academician should hold the "terminal degree" to be in academia but reject the notion that an academician should obtain licensure before being allowed to teach students preparing for the profession of electrical engineering?

I saved this question for last knowing that if one of the preceding comments did not "rile up" the readership of TRANSACTIONS ON EDUCATION, this comment would certainly get the job done.

It amazes me that we, as academicians, are willing to pursue the terminal degree in our field so that we can teach at the university level but so vocally reject the notion that we should be equally willing to pursue legal certification as an engineer. Personally, I want my discipline to be considered to be a profession, and I want my students to view their education in the discipline as preparation for practice in a profession. So, if I am to have a "professional attitude" and attempt to instill in my students a "professional attitude," I need to display the characteristics of a professional, which includes obtaining appropriate licensure and maintaining a current license. To say that my subdiscipline does not require licensure is to avoid the issue of professionalism. To say that the licensure exam does not contain problems from my area of specialization is to say that I am too dumb or too lazy to prepare to pass the licensure exam or that I am out-of-date, which means that I have no business teaching engineering in the first place. Any person having the analytical and study skills required to earn a "terminal degree" has the analytical and study skills required to pass the licensure examination successfully.

Well, enough for now. I will step down from my soapbox and wait for the deluge of e-mail that will result.

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