Engineering Education Is Broken

The problems the world faces in energy, climate, poverty, food and water, health care, and education are complex and multidisciplinary in nature. Their solution requires an *integrated, multidisciplinary approach*, i.e., science + engineering + business + society + managing complexity, which is not the way engineers are educated nor the way companies traditionally function. Only through innovation can these problems be solved. But what is innovation? It is hard to define, but one knows it when one sees it!

Innovate or Perish is a mantra I have heard over the past decade in industry throughout the world. Companies who have heeded the warning have flourished, while others have vanished. *Silos* and *Comfort Zones* are the biggest impediments to innovation, and elimanating them requires changing culture – attitude and behavior – and instilling ownership of the challenge. Innovation is local, not imported but created, and is a way of thinking, communicating, and doing. The same mantra applies to engineering undergraduate education. I have heard it said that is easier to move a cemetery than it is to change an engineering curriculum. Engineering schools for whom that is true might soon be buried in those cemeteries. While that all sounds humorous, it is in fact tragic. Engineering colleges are operating in the past with, in control-system language, a huge time lag. They are ineffective in preparing students for 21st-century engineering problem solving. Why? Engineering schools are siloed, staffed by professors with little or no hands-on practical experience who are content to teach "textbook" courses that are outdated with no multidisciplinary integration. Why? Because they can and it is easy! Add to this the fact that students do not buy or read textbooks, rarely take notes in class, and focus only on exams and grades, relying on the internet to prepare for exams that test a student's ability to memorize how to solve a typical exam question in 30 minutes or less. This is a far cry from actual engineering practice. This does not mean that faculty do not care about their students; I am sure they all do. Show you care and give good grades, and no one complains. But effectiveness is not a consequence of caring. Being effective requires faculty to get out of their comfort zones, i.e., become comfortable being uncomfortable, as they should instill in their students. That is how problems are solved.

In engineering design, a poorly-designed physical system will never be able to give outstanding performance by adding a sophisticated controller. Similarly, traditional course content, even if delivered by the best teachers in the world, is still just information, a commodity. The problem is not the delivery method; the problem is the content of the delivery. Engineering content must be broken apart, updated, rebundled with a balance between fundamentals and industry best practice, continuously reevaluated and, most importantly, *integrated*: mathematics, physics, engineering, and social science / humanities courses from the first year to the fourth year so students experience a four-year journey to become an engineer ready to solve problems and make a difference. That content then becomes knowledge that is not a commodity. It is this knowledge that stimulates students and transforms them into critical-thinking problem solvers resulting in a real competitive advantage in this global economy.

Students go to an engineering college not to study engineering but to *Become Engineers*! That requires engineering faculty to mentor their students from day one to experience engineering and how an engineer thinks, works in a team, and communicates, as well as to emulate the attributes of an engineer, i.e., integrity, selflessness, passion, respect for all, professionalism, and an unrelenting desire to solve problems to help people in need. If the student develops a passion for engineering, he/she must take ownership of the challenge to become an engineer. Without ownership, they will remain high school students unprepared for the future.

Add to all this the top-heavy administrations at almost all schools who think that the university exists for them and who never leave their offices to experience the details of education, the bloated salaries of deans and administrators, the under-appreciated and under-compensated staff, and the ever-growing tuition cost. The students and faculty / staff are the university, and the administration exists to serve them and not the university trustees. Now you see why these engineering schools are headed for the cemetery. Diplomas, even from the most elite schools, are becoming less important, as what matters in the real world is who you are *now*, who others are because of you, and how you will work *now* with others unselfishly, professionally, and with integrity to solve problems to benefit mankind.

After this indictment of present-day engineering education, do I have any final recommendations? Well, yes, I do, but this advice addresses a wider range of challenges. Take ownership of the problem you face and always act with integrity courageously and there is no obstacle that cannot be overcome.

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