Is It Time to Broaden the Definition of Engineering?

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Declining engineering enrollments. Less than 5% of the B.S. degrees in the U.S. were awarded to students who majored in engineering last year. This is among the smallest percentages in the world. Yet engineers are critical to solving the Grand Challenges[1] of our time: global security, sustainability, health, and education, among others. Without engineers to conceive, design, implement and operate the complex systems needed to address these challenges, there is little hope for real progress. Furthermore, U.S. national competitiveness clearly depends on maintaining our lead in technological innovation—which in turn depends largely on our ability to attract talented and creative young people into the engineering field—in each generation. As the demographics of our population change over time, it is essential that the demographics of the engineering profession also change. However, there has been relatively little real progress in this human dimension to engineering in the past 20 years. As a result, national concern continues to rise.

Public perceptions of engineering. For example, the National Academy of Engineering published a report in 2008 entitled Changing the Conversation: Messages for Improving Public Understanding of Engineering. Among other things, this report examines the results of a large opinion survey of teenage students in the U.S. about the field of engineering. It explores public perceptions of what the field of engineering is about, and what messages about engineering are communicated and received by the public at large. The stereotypes of engineering are pervasive and often not very appealing in the marketplace of public opinion. Engineers are often viewed as people who work primarily with math and science to build complicated devices. They are usually viewed as white males, not especially fun, creative or interesting, not as well paid as lawyers or doctors, more interested in things than people, often obsessed with their work (which is perceived as being boring), introverted and disengaged from social or political issues[2]. A current, highly visible example of public stereotypes of scientists and engineers is provided by the popular television sitcom, The Big Bang Theory (which now appears on Thursday evenings at 8:00 PM on CBS)[3]. Obviously, the field of engineering has to overcome these widespread negative perceptions in order to attract serious attention from the talented youth of today.

These public perception issues are likely to have a bearing on the college choices of young people. A recent study in Europe of the attitudes of young people toward careers in engineering indicates that the pervasive trend away from the study of engineering is not due to an inherent dislike of technology or engineering, but instead, is due to the perception that the profession of engineering is not sufficiently

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[1] http://www.engineeringchallenges.org

[2] In a recent NSF funded research project on how children view scientists (and engineers), Professor Diandra Leslie-Pellecky of the University of Nebraska interviewed numerous students about their views of scientists. She encountered many children who believe that the scientists who visited their school aren't real. "They might say the person was too 'normal' or too 'good looking' to be a scientist," Leslie-Pellecky told ***Nature***. "The most heart-breaking thing is when they say, 'I didn't think he was real because he didn't seem to care about us.'" In film and television, scientists are often quirky, nerdy, obsessed, reclusive, self-important, and not infrequently, mad. These are not traits that appeal to kids, she says. (Hollywood or Bust, ***Nature*** 430: 720-722, 12 August 2004.)

[3] Set in Pasadena, California, the show is about two fictional Caltech geniuses, one an applied physicist (Leonard Hofstadter) and the other a theoretical physicist (Sheldon Cooper), who live across the hall from an attractive blonde waitress and aspiring actress (Penny). Leonard and Sheldon's geekiness and intellect are contrasted for comic effect with Penny's social skills and common sense. An aerospace engineer, non-PhD, (Howard Wolowitz) and a particle astrophysicist (Rajesh Koothrappali) are their equally geeky and socially awkward co-workers and friends (description taken from Wikipedia)

attractive in comparison with available alternatives[4]. The role of the engineer, as it is perceived by youth today, is simply not sufficiently appealing to inspire them to dedicate their life to this profession.

Engineering vs. management. The field of engineering as it is practiced today is very broad, encompassing many different kinds of activities and careers. For example, engineers are employed in the technical aspects of design and construction of civil engineering facilities, in the design and development of new aircraft at Boeing, in the development of software for internet companies such as Google and software companies such as Microsoft—and, more recently, in the development of sophisticated mathematical models for financial "derivatives" on Wall Street—where the application of knowledge in the physical sciences is quite remote. Engineers frequently find themselves working for companies led by graduates of business schools whose background does not include science or engineering. Many engineers find that the path toward career advancement requires taking on management and/or leadership responsibilities, which they regard as outside the role of an engineer, in part because the education they received as engineering students did not include exposure to leadership or management subjects. These subjects were considered "soft" since they do not involve the application of mathematics or physical science, and were not included in their required curriculum.

Personal identity. In my experience, many alumni of traditional engineering programs who become successful CEOs of companies often feel as though they have left the field of engineering. When I speak with them, they seem somewhat apologetic that they have abandoned their technical training. They assume that I am disappointed with them for "wasting" all the technical training they received. This sometimes even contributes to a change in their personal sense of identity from that of "engineer" to that of "manager" or "executive" or something else.

Poor graduation rates. A close examination of the actual course requirements for an accredited undergraduate engineering degree at a traditional university shows that about 75% of the courses required involve science, mathematics, or technical engineering subjects. The concentration in these subjects is intense, and the resulting rigor of the academic program often stands out in contrast to most other majors on campus. Engineering students quickly get used to the fact they must spend much more time on homework and projects than their roommates that are majoring in other concentrations. In addition, the heavy emphasis on theory and the sparse opportunity for application (such as a project to build a robot, etc.), often contributes to a high level of frustration among engineering students. As a result, nationally, about half of the college freshmen who choose to major in engineering transfer to some other major before graduation. That is, nationally, about half of the students that we manage to attract into the field drop out and do not graduate in engineering. Furthermore, very few students from other majors consider transferring in. It is easy to see why such a small percentage of the bachelor's degrees in the U.S. is awarded to students majoring in engineering.

The need for more broadly-educated engineers. On the other hand, at the recent 2010 National Summit on the National Academy of Engineering (NAE) Grand Challenges at USC in Los Angeles, NAE President Charles Vest observed that "*this is the most exciting era for engineering and science in human history.*" Today, the emerging applications of science and engineering offer breath-taking opportunities to make a positive difference in the world. We will need large scale innovations based on these new ideas to address the Grand Challenges—innovations that are so profound, that we will not be able to remember the world before they were introduced. The NAE's recent report Educating the Engineer of 2020 notes that the leaders in this process of innovation will need new abilities in teamwork, interdisciplinary thinking, entrepreneurial skill, leadership, and creativity to successfully lead the process of addressing the engineering challenges of the 21st century. This has not been the emphasis of traditional engineering educational programs. We will need more engineers who are broadly educated and able to bridge

[4] Becker, Frank Stefan, "Why don't young people want to become engineers? Rational reasons for disappointing decisions," ***European Journal of Engineering Education***, 35 (4): 349-366 (August 2010).

disciplines to conceive solutions to the challenges that take into account social, economic, political, and even religious dimensions of the problems we face.

This represents a substantial shift in the nature of engineering and in the "DNA" of the engineering workforce of the future. In the past, engineers have assumed that their role is defined by math and science, not leadership. But if engineers don't assume these new leadership roles, who will? Politicians? Lawyers? Business leaders? What professional background provides the best preparation to lead in the process of conception, design, implementation, and operation of the complex systems needed in this century?

Olin's definition of engineer as innovator. Olin College was established about 10 years ago for the specific purpose of developing a new paradigm for engineering education. Part of that process included a deliberate effort to rethink engineering education from the ground up. The accompanying paper, given last June as a keynote address at a national symposium, outlines the results of these efforts and offers a new and broadened definition of the type of engineer that Olin College produces. This new engineer is intended to be well aligned with the competencies needed to address the NAE Grand Challenges and is substantially different from the more traditional type of engineer produced by many other universities. This new type of engineer also appears to be more attractive to talented young people who are seeking a career that they perceive to be important and relevant, and that will open many doors for them.

One of the consequences of Olin's broadened definition of engineering and the new educational model we are developing is that Olin alumni often have different expectations and competencies than their counterparts from more traditional universities. Being among the first into the market with a new product often produces some misalignment and confusion about new features. In general, employers have reported to us (in annual surveys) that they are very pleased with our graduates[5]. However, our alumni have reported that not all companies seem prepared to make good use of the new type of engineer that we graduate. Nevertheless, our alumni have established a remarkable record of success in a wide range of post-graduate pursuits, ranging from graduate school in engineering, science, and other professions, to employment in major technology companies and early stage start-up companies, to founding their own new businesses, and to working for non-profits in order to make a positive difference in the world.

This raises a number of questions which I hope we can address together at the meeting of the President's Council next week. In particular:

1. Is there now an adequately strong case to broaden the definition of engineering—not just at Olin College, but throughout the profession?

2. What role can and should Olin College play in such an effort? What other constituencies should we consult or engage in this effort?

3. What can we learn from other professions, like medicine, in communicating a change in our identity?

4. How can we better engage corporate leaders in a dialogue on redefining engineering? What is the value proposition for large and small corporations in broadening engineering's definition?

5. How can we effectively engage more traditional engineers in the effort to broaden the definition of the field?

[5] Forty percent of employers felt that Olin entry-level engineers performed at levels similar to other engineering graduates with 3–5 years of experience, as reported to us in the 24 month alumni follow-up survey for the Classes of 2006 and 2007.