DIVERSITY IN ENGINEERING EDUCATION

Indira Nair
Carnegie Mellon University
Engineering and Public Policy
Pittsburgh, Pennsylvania

Engineering: the Beginnings

An important starting point when we talk about diversity in engineering education is to ask what engineering education means, and what its roots and modes of propagation are. What makes it hard to retain women at the higher levels of engineering education? Are there inherent elements that make engineering monolithic and disenfranchises students?

Rather than address the total question of diversity in engineering environment, I would like to limit this discussion to the issue of women and engineering education. Some, but definitely not all of the issues may be the same for women and minorities.

Engineering comes from the word "ingenieure": to contrive, to be skillful (at solving problems); and technology comes from the word techne: art. So engineering started as the skillful solving of problems. Engineers trained through apprenticeship rather than by "education". Being practical and strenuous work in older societies, engineering was "man's work". Although engineering found solutions to societal problems, built bridges and roads, it was also frequently patronized, and often made technical advances because of need during time of war. But engineering was mostly "small business," it was non-academic, it still served people's needs most. It was a "civilian trade."

Science on the other hand, started as natural philosophy. It was mostly the pursuit of people who could afford to study. Science was an "ivory tower pursuit" in its early days. The academy was the seat of science. As science developed its predictive mathematical nature, it became possible to do engineering partly in a predictive way. The empirical "trial-and-error" method was still necessary but increasingly, engineering science became the foundation, although not without some resistance on the part of some engineers.

Soon, engineering was deemed to have enough "scholarly" character to be considered as an academic discipline. The first engineering school -- L'Ecole des Ponts et Chaussees -- opened in Paris in 1747. [2]. This entry of engineering into the academy began the first profound change in engineering. The model used to translate engineering into its academic version -- engineering science -- was the model of science. That brought an increasing difference between practice of engineering and the academic discipline of

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engineering gradually over the next century or so.

Industrialization and the prominence of technology, and the advent of mass production also brought about an intimate relationship between engineering and the economy. The human, creative, adventurous element in engineering -- the artistic way -- increasingly became dehumanized and engrossed in economic production [3]. After the second world war, big business also increasingly became identified with military production. The military-industrial complex became the foremost patron of engineering, especially in the U.S. after World War II.

This transition led to a change in the character of the engineering enterprise and of civilian manufacturing [4]. David Noble has described this intrusion of military values into engineering production as "command performance." Engineering became monolithic in conception, hierarchical in organization, "command and control" in character. [5]

What does all this have to do with women and engineering education? A Carnegie Mellon women alumni survey showed several points relevant to women in engineering [6]. Two of these were that many women said they chose engineering because their fathers (or brothers) were engineers. A large number of women also said that only women who were "self-driven to work hard and confident" would choose engineering. Most women also chose engineering because it would help them to serve others. Two observations emerge from this.

a) The observation that most women engineers seem to have had an engineer father (or encouragement from a father) brings up the question as to what aspect of this "birthright" is important in encouraging a woman to become an engineer. Is it the presence of a very influential role model, is it the personal experience of knowing what an engineer’s work involves, or is it that the engineer father provided the right level of support and encouragement?

b) If only "self-driven and confident" women would choose engineering, could we ever hope to have women as 50% of the engineering workforce? The level of about 15% which has been the apparent "equilibrium level" for over 20 years or so may be due to this factor -- it may represent the fraction of confident women! Any increase over this must necessarily come from programs targeted towards mentoring women in engineering and building their self-confidence.

c) A women who chose a career that would help her serve people might also be put off by the close connection between many engineering manufacturing jobs and military production.

Literature describes several aspects of the engineering work and education environment that deters women from engineering. The nature of the enterprise being competitive rather than cooperative, the "invisibility" or sometimes, the attention being the only woman in class brings, the analogies and examples in classes which uses sports or other unfamiliar contexts, the image of the "quintessential
engineer" as a man are some of these.

Feminist literature on learning science and on the edifice of science describes a lot of these. [7,8]. Perhaps the most important work is Sue Rosser's "Female-friendly Science" that systematically discusses science education and methods that would make it more inclusive of women and minorities. [9]. It should be required reading for engineering and science teachers.

Rosser describes the aspects of the science and engineering classroom that turn many students including women off. Some of these are "distancing from the object of study," "separate, knowing" (rather than knowing all the connections), "moving on" (women prefer to prolong the observational stage), validity of personal experience and the importance of applications.

Rosser recommends classroom approaches that pay attention to language, a mode of critique that do not turn students away, teaching the structure of the knowledge in a relational, interdependent, multicausal way as opposed to a hierarchical, reductionist, dualistic way, emphasizing cooperative rather than competitive work, and teaching the subject in its social context.

Many of Rosser's suggestions for science would be applicable to engineering teaching as well. In addition to support programs that function primarily outside the classroom, a change in the classroom environment might make engineering better not only for women but for all students.


