AC 2007-436: IT TAKES A VILLAGE TO CHANGE THE PERCEPTION OF ENGINEERING

Susan Metz, Stevens Institute of Technology

is Senior Advisor of the Center for Innovation in Engineering and Science Education (CIESE) at Stevens Institute of Technology. Throughout her career, Susan has worked to increase the participation of women in engineering and science. As the founding executive director of the Lore-El Center for Women in Engineering and Science at Stevens she developed and implemented pre-college and college level programs to increase the representation of women in STEM fields at Stevens and nationally, serving more than 15,000 women. In recognition of this contribution, the Lore-El Center received the White House Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM).

Susan is a co-founder of WEPAN, Women in Engineering Programs & Advocates Network, a national organization whose mission it is to enhance the success of women in engineering across all levels. As a leader of WEPAN's training seminars, Susan worked with nearly 200 colleges and universities to increase access and degree completion of women in science, technology, engineering and mathematics (STEM) fields. She served as president of WEPAN for five years and received a second PAESMEM award on behalf of the organization's accomplishments in 2003.

Susan served as principal investigator or co-principal investigator of several national projects including: Project to Assess Climate in Engineering (PACE), a current study involving 25 universities; FacultyfortheFuture.org, a website designed to support women and underrepresented minorities interested in pursuing faculty positions in the STEM fields; Achieving Success in Academia, a program to assist junior women faculty to navigate the tenure system; Making the Connection, an initiative designed to increase awareness of engineering among students in grades 3-12; and Increasing Access for Women in Engineering, a curriculum and technical assistance project to establish or improve women in engineering and science programs created to increase enrollment and retention on university campuses. In 2003, Susan was the recipient of the Maria Mitchell Women in Science Award and in 2007 was recognized by the Association for Women in Science as an AWIS Fellow.

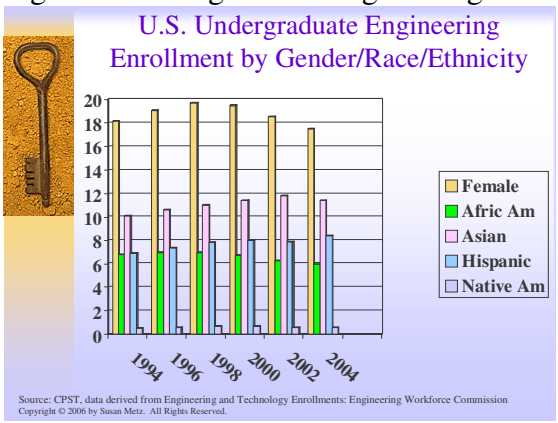
Susan has participated on numerous advisory boards for organizations some of which include: National Academy of Engineering, National Science Foundation Engineering Directorate, AAAS' Center for Advancing Engineering and Science Capacity, Boston Museum of Science's National Center for Technological Literacy, Clare Boothe Luce Program, American Association of Engineering Societies, MentorNet, Society of Manufacturing Engineers National Youth Council, Boston University's Women in Science and Engineering Faculty Advisory Board and Johns Hopkins University NSF Curriculum Reform Implementation Grant

It Takes a Village to Change the Perception of Engineering

Susan Staffin Metz
Stevens Institute of Technology

The decline of women in college engineering programs continues to be of great concern given the demographics of the US workforce that predicts that by 2010, 67% of the entrants into the workforce will be women and minorities (see Figure 1).[1] At the baccalaureate level, women dominate the ranks, earning 56% of the undergraduate degrees in 2002.[2] Women earned nearly half of all degrees in law (48%) and medicine (46%), 41% of the masters in business administration, 36% of Ph.D.'s in natural science, but only 18% of the engineering doctorates in 2004.[3] Why are women attracted to professions, many of which are math and science based, but rarely consider engineering as a career choice?

Figure 1: Undergraduate Engineering Enrollment



In 2003, the American Association of Engineering Societies (AAES) commissioned a Harris Poll to determine the public's understanding and attitudes about engineering. According to the poll, 66% of Americans feel they are *not very* or *not at all well informed about engineering and engineers*. Women were less interested in engineering than men with 28% indicating they were *very* or *somewha*t interested compared with 53% of men.[4] Many factors dissuade women from engineering. The traditional and pervasive stereotypes evident in common sources of information pertaining to what engineers do and who engineers are continue to haunt the engineering profession. Since engineering is virtually absent from the K-12 education curriculum in the US, there is greater reliance upon other information sources.

How do we engage students, particularly women and minorities, to consider engineering as a career? Jolly, Campbell & Perlman propose a trilogy of characteristics that are necessary for students to advance in the sciences and math based fields, including: [5]

- *Engagement*: An orientation to the sciences and/or quantitative disciplines demonstrated by awareness, interest and motivation.
- *Capacity*: The knowledge and skills needed to advance to increasingly complex content in the sciences and quantitative disciplines.

- *Continuity*: Access to institutional and programmatic opportunities, material resources and guidance that support advancement to increasingly complex content in the sciences and quantitative disciplines.

While the level of each characteristic can vary, all are required for an individual to pursue an engineering career. Girls graduate from high school with skills and knowledge equivalent to those of their male peers. However, substantially fewer girls continue in engineering and the physical sciences which suggests distinct differences in engagement between boys and girls. Recent increases in girls' enrollment in math and science courses in secondary school and their rising achievement overall have not corresponded to increases in their participation in the physical science and engineering fields.[6] Research indicates that female high school students are less interested than male students in science and engineering education and in their related careers.[7] Therefore, while it remains important to improve continuity and capacity for all students, engagement is the key to getting more women involved in engineering.

Evidence suggests that the two types of engagement most influential to women in this context are: 1) emotional engagement defined as a positive reaction to people, content and environment in the academic setting, and a view of the discipline as fun, intriguing and intellectually rewarding;[8] and 2) vocational engagement as having a perspective of the profession as fulfilling to an individual's aspirations with a variety of longer-term rewards.[9]

A recent study conducted by WGBH Educational Foundation to better understand what attracts high school women to engineering identifies the following key issues and findings: [10]

- High school girls believe that engineering is for people who love math and science. They don't have an understanding of engineering, show an interest or think it is for them.
- Engineering is portrayed as very challenging with an emphasis on the importance of superior math and science skills. Messages do not include benefits and rewards of being an engineer.
- Professional interests for girls hinge on relevance - the job is rewarding and the profession is for someone *like me.*
- Career motivators for high school girls include: enjoy their job, have a good work environment, make a difference, earn a good salary, and have flexibility.
- High school girls react positively to personal and informational stories. Descriptions of engineering need to be better aligned with their career motivators.

These high school girls tell us that it is important to:

- Share stories of how people's lives have been affected by engineers.
- Describe how engineering is not just about drafting and cars...it can be about social issues, and third-world countries becoming better and citizens happier.
- Talk more about the positive aspects of engineering such as hands-on fun, traveling the world, making a difference, seeing your creations come to life.
- Point out that engineers not only make good money, but also contribute to the well being of the human race.

Consider Margolis and Fisher's findings regarding a student's decision to major in computer science. They found that women consider numerous factors while men consider only a few of these factors. *Computing with a purpose*, the concept of using the computer as a tool to enable processes and solutions that impact human and social contexts, make the study of computer science compelling and meaningful to women. Nearly half (44%) of the women interviewed and only 9% of the men link their interest in computing to areas outside of the hardware and software. The image of a computer science student was another aspect that Margolis and Fisher explored. They asked male and female students to provide descriptions of the typical computer science student. About 50% of all respondents said that the image of the computer science student *is not me*. Gender differences are telling with 69% of the female and 32% of male computer science majors viewing themselves as different from most of their peers since their life does not revolve around the computer. Consequently, nearly two-thirds of the women question whether they belong in computer science because they do not identify with the typical male computer science student. [11]

Where do people obtain information about engineering and what do they learn?

There is a multitude of outreach programs, websites and publications that have done an outstanding job conveying engineering in a relevant and compelling way. Many engineering focused organizations have revamped website content, brochures and newsletters to increase awareness among students, parents and educators about the broad range of career opportunities in engineering. However, a great deal of inconsistency remains and it is important to identify existing problems so they can be effectively addressed.

The Engineer of 2020 emphasizes the versatility of an engineering education and enthusiastically demonstrates the intrinsic reward of improving the quality of life for people.[12] Furthermore, it points out that young people, their parents, and counselors remain unaware of the numerous and diverse opportunities offered by an engineering education. Key attributes of an engineer depicted in *The Engineer of 2020* include strong analytical skills, practical ingenuity, creativity, communication, business and management, leadership, high ethical standards, professionalism, dynamism, agility, resilience, flexibility and lifelong learners. These characteristics would attract a broad spectrum of students. The combination of these attributes and multiple career opportunities is a far cry from the traditional and linear descriptions of engineering that must be dispelled. How messages are crafted and presented cannot be underestimated when it comes to attracting or repelling students from the profession.

Google has emerged as a verb in the English language. The number of teenagers using the Internet has grown 24% in the past four years and 87% of those between the ages of 12 and 17 are online.[13] In 2006, 71% of adult women and 74% of adult men are Internet users. Disaggregating the data by race and ethnicity reveals that substantial segments of the population access the Internet including 73% White/Non-Hispanics, 61% Black Non-Hispanics, and 76% of English-speaking Hispanics.[14] With such a high level of Internet users, it is not surprising that a website is increasingly the place where people get that vital first impression.

Descriptions of engineering on popular websites present messages that deter students, particularly women and minorities from engineering. This problem is compounded by the high

degree of Internet usage combined with the millions of web pages that exist on the subject. We need to be particularly concerned about mass-market websites and other forms of media that address the mainstream target populations in which other information sources such as mentors and educators may be absent. Conversely, if those messages are well crafted, students will likely continue to the next tier of information, perhaps to websites of organizations specifically affiliated with engineering. This tier might include professional societies, university schools of engineering and other non-profit groups. Attracting students to engineering who are largely unfamiliar with the field is a challenge, especially when students and their advisors are inclined to rely on traditional stereotypes to fill in the information gaps. Often, a website, article, presentation, or other communication has limited potential to spark enough interest in the field to encourage a prospective engineering student to seek more information. If the message fails, the student is likely lost to another profession.[15]

Case Studies

Three websites are used as case studies to emphasize the need for consistent messages about engineering that are engaging. These websites offer a tremendous opportunity to attract a broad segment of the student population to engineering, but only with well-developed messages. Unfortunately, based on what we know attracts non-traditional students to engineering, and in particular women, their messages fail to engage this audience. We will explore why. PrincetonReview.com was selected because it is a nationally recognized, well-respected organization that provides a myriad of information and resources in preparation for college. The CollegeBoard.com website was chosen because it appears on the 1st Google page when a search for college majors is requested. In addition, the site is used by millions of parents and students interested in college regardless of field, since registration for SAT tests are handled through this site. WorldWideLearn.com was selected because it is listed on the second Google page when requesting a search on college majors. Electrical engineering was chosen as a focus of the case studies since it is one of the largest undergraduate engineering majors and a major that attracts a lower percentage of women (13.1% in 2004) relative to other engineering disciplines.[16]

PrincetonReview.com

PrincetonReview.com offers users an extensive collection of information about colleges, testing, tutoring and career opportunities. The college major section includes descriptions of hundreds of majors including many engineering disciplines. It gives a basic summary of the major and then describes the high school preparation needed to pursue the major. Here is an excerpt from the web page about electrical engineering: [17]

Electrical Engineering Basics
Think MacGyver here: Is it the red or yellow wire to deactivate (or activate) the bomb? Does the answer seem obvious to you? Perhaps you're an electrical engineer in the rough.

Electrical engineers design, develop, and test electrical equipment. They figure out ways to generate and control electrical energy. Electrical engineers work with every kind of device imaginable, from computers to clock radios to global positioning devices. They also really know

the difference between amperage (strength), voltage (force), and wattage (power) of a current, and can toss off these terms and others with ease.

Suggested High School Preparation

Electrical Engineering is a math and science-heavy field. Take physics and as many advanced math classes as you can. Additional experience in programming languages is very helpful, but certainly not required. And be sure to watch a lot of MacGyver reruns.

This description is extraordinarily limiting and may appeal to students who fit the typical engineering profile. This text is trying to convey a sense of humor but it is dated and may be a turn-off to many students and in particular, women. Students who watch reruns of MacGyver might find this amusing but many may not even know who he is. This criticism sounds trivial but for students and parents who are unfamiliar with engineering, this is a characteristic that they may grab onto to help them decide whether to explore this discipline further. The sarcasm continues with the sentence, *they also really know the difference between amperage (strength), voltage (force), and wattage (power) of a current, and can toss off these terms and others with ease.* When descriptions of engineering are developed, it is important to integrate what we understand girls want to know about engineering. This text misses the mark. Young women want to know that the field they pursue can positively impact people's lives and that it is for someone *like me* .[18] Electrical engineering can be described with these concepts in mind rather easily. In the absence of accurate information and a breadth of understanding of the profession, students, parents and educators explore websites for reasons to engage or disengage. This content minimizes and diminishes electrical engineering to knowledge about amps and volts, reinforces stereotypes, and represents a missed opportunity to inform and engage readers.

CollegeBoard.com

The College Board website is a large repository of information on colleges, careers, college majors, financial aid and standardized testing. The users are typically students, parents and educators across a wide spectrum of interests. Under the link to electrical engineering there is a section developed to help students assess whether electrical engineering may be a good fit for them, which reads: [19]

Are You Ready To…?

- *Juggle projects, lab exercises, and reading assignments*
- *Spend hours building detailed, complicated systems*
- *Design your own gadgets or software*
- *Try, try, and try again when at first a project doesn't succeed*
- *Work as part of a team*
- *Write reports and give oral presentations*
- *Do an internship in which you'll have real job responsibilities*

This description of electrical engineering stresses the wrong things if you consider the research cited in this paper. The concept of social relevance is absent from the text. Electrical engineering is limited to gadgets and software. What impact does the field have on people's quality of life? Will students be intimidated, bored or simply put off by the focus on *try, try again…or spend hours building complicated systems?* This message speaks to students with

very traditional interests in engineering. After reading this passage, will students, parents and educators be compelled to seek more information about electrical engineering? A better strategy might be to emphasize the contributions of the field and the excitement of discovery and innovation rather than the tedium of the process.

WorldWideLearn.com

WorldWideLearn.com describes itself as the *World's Premier On-Line Directory of Education.* The section about electrical engineering offers information to help students decide whether or not to pursue this major. Here is an excerpt from the web page: [20]

Is Electrical Engineering Right for You?
If you enjoy taking things apart, seeing how they work, and then putting them back together again, electrical engineering might be a good career choice for you. If you've often wondered what makes your computer compute and you have a vested interest in math and science, pursuing an engineering degree should be a serious consideration.

Electrical engineers aren't just "techies." While engineers often work in the technology services arena, their tasks range from designing and building medical equipment to working for the military or department of defense. Contrary to popular belief, electrical engineers don't just sit in their labs alone, tinkering with their latest invention. Electrical engineers often work in groups, so a great deal of teamwork is required from them.

Do you have to like to take apart things? Is this the primary criteria that a student should use to assess their capacity for an engineering career? The statement, *their tasks range from designing and building medical equipment to working for the military or department of defense* is poorly chosen. People who are unfamiliar with electrical engineering do not know what fits within this range. Citing *military defense* in the description conjures up very limiting and unappealing images to many students, particularly women. Again, this message targets the traditional engineering student. The characteristics identified in this description should be broad enough to engage a variety of academically qualified students. It ignores countless others who would major in the discipline if different characteristics were emphasized. The description about teamwork is laudable, but again there are much more exciting ways to portray how electrical engineers go about their business to create life-changing processes, systems, materials and goods while considering the constraints of economics, politics, and human and environmental factors.

Take Advantage of "Teachable Moments"

It is important to find ways to gain access to mass media and mainstream news that targets large segments of the population generally unfamiliar with engineering. For this reason, when a *teachable moment* arises, we need to capitalize on the opportunity. As an example of a lost opportunity to dispel stereotypes and present science and engineering in a favorable light, *TIME* magazine, a mainstream well-respected magazine published an issue this year with the cover story, *Is America Flunking Science?* [21] The picture on the cover depicts a young white boy in front of a science lab bench with a charred and somber expression as he contemplates the glass beaker (see Figure 2).

Figure 2. TIME Magazine Cover

The cliché a *picture is worth a thousand words* could not be truer and more damaging in this case. For those who saw this *TIME* magazine cover but did not read the articles, it merely reinforces long-held stereotypes.

Another example of a piece that reinforces rather than dispels stereotypes can be found in a recent ad in the *Chronicle of Higher Education.* The ad targets college faculty who use technology in the classroom as a teaching tool. The *Chronicle* is arguably the most widely read weekly newspaper among the higher education community regardless of field. This represents a cross-section of faculty in all disciplines. A technology company had the opportunity to show a diverse group of students in this picture, dispelling stereotypes of students and technology. Instead, every English, sociology, history and fine arts professor who leafed through the *Chronicle of Higher Education's* pages caught a glimpse, even if only subliminally, of this image revealing the message that no people of color or women are connected with technology (see Figure 3). [22]

Figure 3: Chronicle of Higher Education Ad

One strategy to increase interest among students in engineering heralded for some time is for engineers to be lead characters in a prime-time television show. This model has possibilities since it seems to have worked well with the *CSI* shows. Countless forensics science majors have been added to academic programs since *CSI Miami* and *CSI New York* became popular shows. Interestingly, in July 2006, the *Chronicle of Higher Education* carried an article entitled *The Problem with Numb3rs.*[23] The author takes a look at the CBS show NUMB3RS which at first glance seems like a great opportunity to show how mathematics has relevance and benefits society in criminal investigations. The lead character uses equations rather than weapons, violence and interrogations to solve crimes. Texas Instruments Inc. and the National Council of Teachers of Mathematics have used some of the shows' math content in their educational program *We All Use Math Every Day* for middle and high school students. Yet one critic of the shows' impact on young people points to the fact that it reinforces the stereotype that you have to be a genius to do mathematics. In addition the lead character is male and a bit eccentric. Although on a positive note, *Numb3rs* does help address the question often asked by students, *when am I ever going to use math in my life*, the opportunity to dispel some fundamental stereotypes has been lost.

Conclusion

Organizations who disseminate information about engineering must be diligent about conveying knowledge that embraces rather than excludes students of all demographics. When occasions arise that provide access to people outside of engineering, we need to capitalize rather than squander those opportunities. It is critical to safeguard the information we deliver. We all benefit. Colleges and universities might consider devoting a segment of their website to properly educating students, parents and educators about engineering. Engineering needs to speak with one voice that is consistent and based on what we know attracts students to the field. Messages matter. We need to create and transform engineering messages to be a benefit and not a liability.

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