

## Beyond the Leaky Pipeline:

### Gender Roles in Engineering Education and Professions

#### *Abstract*

Engineering is a field in which mathematical and scientific skills are heavily required, with top engineers acquiring highly respected reputations and earning substantial salaries. It is also an extremely male-dominated field, although there have been some efforts to bring women into engineering. A “boy’s club” stigma still seems to be attached to engineering classrooms and professional labs across the country and world. This paper will examine the theories that attempt to explain this phenomenon, look at the actual experiences of female engineering students and engineers through online “blogs,” discuss what is being done to bring more women into the field and what can be done in the future.

#### *Introduction*

It is a common stereotype that men are superior to women in the fields of math and science. The basis for this stereotype might lie in the lack of women studying these technical subjects at the high school and university levels and subsequently selecting out of the fields of math and science when they choose their careers. Women make up only 25% of individuals who earned a bachelor’s or higher degree from a university who are employed in a science or engineering-based occupation. Within the engineering field alone, only 10% of positions actually involving engineering are held by women.<sup>1</sup> Upon graduation, women with engineering degrees are more likely than men to go into academia; men are more likely to enter business or

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<sup>1</sup> National Science Foundation. National Science Foundation, Division of Science Resources Statistics, (n.d.). Women, minorities, and persons with disabilities in science and engineering. Retrieved Oct. 02, 2005, from <http://www.nsf.gov/statistics/wmpd/>.

industry. On a societal level, the engineers who work in business and industry enjoy more prestige than those in academia and they tend to make more money.<sup>2</sup>

Why are there so few women in engineering? It is not because women are inherently not “good” at science or because they do not “like” science, math, or technology.<sup>3</sup> The few women who do make engineering their career often find themselves not only doing the technical work in their groups but also performing relational tasks such as project management, conflict resolution, and relationship building.<sup>4</sup> While these functions are vital to the completion of groups’ tasks and the success of any team, they are seen as auxiliary and menial, if they are even seen at all. Therefore, raising the status of women in these organizations to the level of their male counterparts is an extremely challenging endeavor. Although the traditional roles of men and women in the workplace and in society have deep roots in our history, it is important to see how these roles limit the potential for women to achieve the same level of success in engineering as men and to understand how to change the culture of a field with such long-standing practices as engineering.

#### *Gender Roles: Hegemonic Masculinity and Emphasized Femininity*

Before looking at the implications of gender roles in an organizational context, and before looking at ways to change organizational cultures to be more open to or inclusive of women, it is necessary to develop a theoretical perspective on gender socialization that helps us understand why we associate certain roles and characteristics with gender. Reviewing research on gender roles and assumptions may help us understand the inequality between male and female

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<sup>2</sup> National Science Foundation

<sup>3</sup> See Margolis & Fisher, 2001, for a thorough study of the educational trajectories of women in computer science, from grade school to university)

<sup>4</sup> Fletcher, J. K. (1999). *Disappearing acts: gender, power, and relational practice at work*. Cambridge, MA: MIT Press.

engineers. R.W. Connell developed the theory of “hegemonic masculinity” to explain the nature of the unequal relationship between men and women. The term hegemonic is defined as “a social ascendancy achieved in a play of social forces that extends beyond contests of brute power into the organization of private life and cultural processes.”<sup>5</sup> Although the oppression of women may not be violent or malevolent, hegemonic masculinity states that women are subordinate to men. Although not all men act superior to women, most men reap the societal benefits of being male in some way.<sup>6</sup> By definition, that which is inferior cannot be hegemonic so there is no “hegemonic femininity.” Instead, Connell describe the female characteristics that exist under the superiority of hegemonic masculinity as “emphasized femininity.”<sup>7</sup> Among the characteristics attributed to emphasized femininity are “compliance, nurturance and empathy.”<sup>8</sup> In engineering, these qualities are usually not as important as technical skill and are often attributed to all women regardless of their actual abilities and personalities. It is important to note that not all men exhibit hegemonic masculinity; those whose characteristics fall outside the dominant male attributes are in a category called “subordinate masculinity.” For example, hegemonic masculinity is stereotypically heterosexual behavior, so homosexual men are a subordinate masculine group because homosexual men do not have the same dominant status as their heterosexual counterparts in today’s society.<sup>9</sup> The phenomenon of hegemonic masculinity is clearly present in the engineering culture where women are often treated unequally and with less respect than male engineers.<sup>10</sup>

### *Engineering and Gender: Theoretical Framework and Observations on Blogs*

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<sup>5</sup> Connell, R. W. (1987). *Gender and power*. Stanford, CA: Stanford University Press, Connell, R. W. (1987), 184

<sup>6</sup> Donaldson, M. (1993). What is hegemonic masculinity. *Theory and Society*, 22(5), 343-357.

<sup>7</sup> Connell, 186

<sup>8</sup> Connell, 187

<sup>9</sup> Connell, 186

<sup>10</sup> See the following section of Connell’s *Gender and Power* for evidence.

Faulkner sees gender in engineering as structured around a series of dualisms such as technical vs. social, concrete vs. abstract, and specialist vs. heterogeneous.<sup>11</sup> These dualisms do not entail inherent gendered characteristics, but in engineering, males and females typically find themselves on opposite sides of each dualism. The technical/social dualism (also called technology-focused vs. people-focused) is particularly interesting when looking at gender issues in engineering. The technical/social dualism implies that some individuals are more interested in technology, or “relationships” with machines, while others are more focused on people, or interpersonal relationships. Given the anthropological and sociological distinctions between “masculine instrumentalism and female expressiveness,” women are typically placed on the social side of the dualism and men on the technical.<sup>12</sup>

A large part of the technical/social dualism is the image of the “male hacker,” the teenage or older male who is obsessed with computers or science to the point that he shuts out everything else in his life and sits in front of his computer screen all day long. Faulkner suggests that one reason men become myopically focused on technology is because they have difficulty with human-to-human interaction, so “intimacy with the machine is a retreat from the vagaries of intimacy with humans.”<sup>13</sup> It is important developmentally for people to cultivate a variety of interests and social interactions, but in engineering, the lines between vocation and avocation tend to blur until they disappear entirely. When women attempt to enter this arena, they find that if they do not spend every waking moment of their lives with their work they are seen as unfocused, but if they do become obsessed with the machines, they are known as “nerds” among their peers and are viewed as unfeminine. This “gender inauthenticity” is what detracts many

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<sup>11</sup> Faulkner, W. (2000a). Dualisms, hierarchies and gender in engineering. *Social Studies of Science*, 30(5), 759-792.

<sup>12</sup> Faulkner 2000a, 762

<sup>13</sup> Ibid.

women from the field of engineering; women in that world can be either female or good at what they do, but not both.<sup>14</sup>

Faulkner discusses the actual experience of the engineering profession for males and females. It is, however, also important to gain a theoretical perspective as to why these dualisms and hierarchies are manifest in the engineering workplace. Through her observations of women engineers, J.K. Fletcher developed a theory of human interaction and growth she calls *relational theory*. The basic premise of the theory is that the interpersonal connections and community-building within groups is done “invisibly, without acknowledging either the support or the need for it.”<sup>15</sup> In the workplace, the majority of the “relational work” is done by the women within the organization, but women are often not recognized for doing this work because it is seen that this work is naturally female and therefore does not require skills or talent on the part of the individual. Among the relational skills identified by Fletcher are the ability to empathize and understand others, a sense of vulnerability and the ability to admit what is unknown, the ability to help others grow in their knowledge, and the ability to think “holistically,” looking at the broader picture and taking into consideration the human aspect to their work. Although not all women possess all these abilities, Fletcher found that these skills are not taught to men so the responsibility for the relational work in engineering teams tends to be the responsibility of the women.<sup>16</sup>

It is important to understand how these theories are actualized in engineering programs and professions. One way to learn about women’s feelings about and daily experiences in engineering is to look on the Internet. Some women are posting their experiences for anyone to read in an online diary, commonly referred to as a “blog.” Most of these blogs have a variety of

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<sup>14</sup> Faulkner 2000a

<sup>15</sup> Fletcher 1999, 33

<sup>16</sup> Fletcher 1999

topics, not just workplace experiences, but reading through them can provide insight into the daily challenges and issues facing female engineers.

A woman named Jacelyn who works as an aerospace engineer in Singapore writes in her blog about her frustrations with her company. She says that not only is she a female, but since she is also young and relatively inexperienced, she often finds her work being devalued and disrespected. When she wrote an article for her company's newsletter, her work was criticized even though she worked very closely with her older (presumably male) mentor on the article. She describes another experience in which she was told that since one of her work team members would soon be returning to the office, she did not need to do "so much." Jacelyn writes in her blog that her superior's comments enraged her because she wants to learn as much as she can. She feels that instead of being treated as an equal, people seem to look at her as if she were "a temp engineer or secretary."<sup>17</sup> Jacelyn's experiences show how the knowledge of a female engineer is often not valued in organizations as much as the knowledge of her male peers.

One blogger (a person who has his or her own blog) named Desiree writes about her trepidation about graduating from college and entering the engineering field. She says that in two of her upper-level classes, she is the only female, and when she enters the classroom, "the whole atmosphere changes...almost like I missed something."<sup>18</sup> She admits that at times, she feels as if she does not belong in the engineering culture and does not see that the problem will ever completely go away. She is probably just as capable as her male counterparts, but due to her gender she sees that her chances of succeeding in the engineering field may be diminished.

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<sup>17</sup> Jacelyn. (2005, July 14). Jacelyn. Retrieved Oct. 11, 2005, from <http://jacelynvega.blogspot.com/2005/07/have-you-lost-faith-in-charities.html>

<sup>18</sup> Desiree. (2005, Oct. 11). Getting to know me. Retrieved Nov. 01, 2005, from <http://toknowdesiree.blogspot.com>.

Reading Desiree's blog, we can see how hegemonic masculinity affects the expectations and experiences of female engineers.

In addition to reading the blogs of female engineers and engineering students, it is also useful to look at what men in the field are saying. The reactions of male engineering students to initiatives meant to bring women into the field are especially interesting. Nick, a mechanical engineering major at Colorado State University at Fort Collins writes:

Do you know why only 10% of engineers are women? BECAUSE THERE ARE VERY FEW WOMEN WHO WANT TO BE ENGINEERS!!!!!! [sic] No one is keeping women from being engineers, we don't turn any away. Women just naturally don't like engineering. I'm not saying that women are not capable of being engineers. In fact, many of the lady engineers I know are smarter than I am! So it's not that they lack the ability, they lack the desire to be engineers.<sup>19</sup>

Although Nick does not feel that men are smarter than women, even in technical fields, he does seem to lack the understanding of the complex process by which women are brought into engineering and other technical fields from youth to adulthood. As a woman progresses in her education, any interest she may have in math, science, technology, and/or engineering [MSTE] is often stifled and discouraged, consciously or not, by peers as well as superiors such as parents and teachers. For example, at the college level many engineering professors will call female students by their first names but refer to male students as "Mr.," which sends the message that

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<sup>19</sup> Nick. (2005, Sept. 21). Nick's Party Corner. Retrieved Nov. 01, 2005, from <http://nickspartycorner.blogspot.com/2005/09/why-are-people-so-stupid.html>.  
Society of Women Engineers, (n.d.). Society of women engineers. Retrieved Oct. 07, 2005, from [http://www.swe.org/stellent/idcplg?IdcService=SS\\_GET\\_PAGE&nodeId=5](http://www.swe.org/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=5).  
Society of Women Engineers – Cornell University. (2005). Society of women engineers. Retrieved Oct 29, 2005, from <http://www.swe.cornell.edu/index.html>.

the men are to be respected more than the women.<sup>20</sup> And even more women lose their interest in math and sciences before they graduate from high school; they self-select out of the field and do not get the opportunity to see what they can accomplish.

*Widening the Pipeline: Attracting Women to Engineering*

As Atkins, Green, and McLaughlin note, “the process by which individuals enter, progress through, and leave MSTE educational programs and science and engineering careers is often likened to a pipeline.”<sup>21</sup> The pipeline metaphor assumes that members of underrepresented groups (women, non-Asian minorities) might have been interested in MSTE at a young age, but as they go through the education system, the pipeline gets narrower or “leaky” until practically no underrepresented groups are present in MSTE.<sup>22</sup> Although women may have an interest in MSTE fields, these interests are not nurtured by their parents or teachers as they get older. In the classroom, there are few visible female engineering role models for young women, and often in classrooms women are not allowed the same access to the technological equipment as their male counterparts due to (conscious or sub-conscious) biases by the instructors or male students. Without a strong support system encouraging them to succeed, women will often discard their interest in MSTE in favor of educational and career paths that are more socially accepted and stereotypically “female.”<sup>23</sup>

People who are interested in broadening the spectrum of representation in MSTE fields often discuss how to keep the pipeline open throughout a student’s education. It is often not that women dislike MSTE, but that they are discouraged from the fields for a number of reasons at a

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<sup>20</sup> Jenkins, C. R. (2003). Attracting young women to careers in science, technology, engineering, and math: in her own words. *Women in Higher Education*, 12(6), 22-26.

<sup>21</sup> Atkin, A. A., Green, R., & McLaughlin L. (2002). Patching the leaky pipeline. *Journal of College Science Teaching*, 32(2), 102-108.

<sup>22</sup> Muller, C. B., & Staffin Metz, S. (2002). Burying the pipeline and opening avenues to engineering. *Prism: American Society for Engineering Education*, 12(4).

<sup>23</sup> Atkins et. al., 2002

number of points along the pipeline. Some methods to widen the pipeline at the high school and university level include job shadowing other women (and/or minorities) in MSTE fields, displaying literature and posters about young women in MSTE careers, hosting social events that require women to use MSTE in a real-world context, and creating campus organizations for women such as a local chapter of the Society of Women Engineers.<sup>24</sup>

The pipeline metaphor, however, is not without its flaws and criticisms. Muller and Metz note that the solution to the problem cannot just be to widen the pipeline near its beginning (at the lower education levels). Since many women do not know at the age of 17 exactly what they want to do with the rest of their lives, it should be recognized that other entry points to the “pipeline” should be available throughout a young person’s educational career. Instead of focusing on a model that requires young people to choose their life’s occupational path, Muller and Metz propose a variety of methods to attract women to MSTE, specifically engineering, at all education levels. They suggest this can be done through transfer, dual-major, or planned studies (where students design their own major) programs at the university level.<sup>25</sup> If a woman lacks some of the science and math prerequisites that many engineering programs require, a planned studies program might help her tailor her degree to her interests and allow her to take lower-level math and science before moving on to the higher level engineering courses.

A number of organizations are dedicated to the advancement of female engineers, such as the Society of Women Engineers or SWE and Women in Engineering, a subgroup of the Institute of Electrical and Electronics Engineers.<sup>26,27</sup> The goal of these groups is to provide resources for female engineers and to create a non-threatening, open environment for women who want to

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<sup>24</sup> Jenkins, 2003

<sup>25</sup> Muller and Metz, 2002

<sup>26</sup> <http://www.swe.org>

<sup>27</sup> <http://www.ieee.org/portal/site>

enter the field. For example, SWE's mission is "[to] stimulate women to achieve full potential in careers as engineers and leaders, [to] expand the image of the engineering profession as a positive force in improving the quality of life, [and to] demonstrate the value of diversity."<sup>28</sup> The SWE website provides information regarding education at all levels and is a place where female engineering students can get information about starting a local SWE group on their campus. Today, many of the top engineering colleges in the country have chapters of SWE on campus for female engineering students. An example of a campus SWE chapter is the one at Cornell University.<sup>29</sup> At Cornell, female students in all engineering disciplines have the opportunity to come together and network with professionals, discuss current issues in the field, and get information about internships and job openings. They can also build personal relationships with each other and the local community through informal social events and volunteer opportunities.<sup>30</sup> In many organizations, the social networks between colleagues help facilitate learning and make individuals feel more comfortable in the organizational culture. These networks are especially important for women and minorities, because they are often seen as the "tokens" in the company and have difficulty assimilating. Social networks among underrepresented groups in organizations are beneficial in that they can give members the confidence to succeed in the organization (Mehra, Kilda, & Brass, 1998).<sup>31</sup>

### *Issues in Professional Practice*

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<sup>28</sup> Society of Women Engineers, (n.d.). Society of women engineers. Retrieved Oct. 07, 2005, from [http://www.swe.org/stellent/idcplg?IdcService=SS\\_GET\\_PAGE&nodeId=5](http://www.swe.org/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=5).

<sup>29</sup> Society of Women Engineers – Cornell University. (2005). Society of women engineers. Retrieved Oct 29, 2005, from <http://www.swe.cornell.edu/index.html>.

<sup>30</sup> Ibid.

<sup>31</sup> Mehra, A., Kilda, M., & Brass, D. J. (1998). At the margins: a distinctiveness approach to the social identity and social networks of underrepresented groups. *Academy of Management Journal*, 41(4), 441-453.

Title VII of the Civil Rights Act of 1964 protects against discrimination based on “color, religion, sex, or national origin.”<sup>32</sup> The legislation also created the Equal Employment Opportunity Commission as a subgroup under the Department of Labor charged with responding to allegations of discrimination in the workplace. The law extends not only to hiring practices but other “personnel actions” such as promotions, benefits and training opportunities. In addition, Title VII defines and prohibits sexual harassment in the workplace and makes illegal workplace discrimination against pregnant women. However, the law only applies to organizations with 15 or more employees and does not apply to religious organizations or employees working in other countries.<sup>33</sup>

Although the legislation has certainly helped decrease the amount of discrimination in the workplace, especially at the hiring level, unless an environment is blatantly sexually inappropriate, a woman often has little power to relieve the pressure and subtle discrimination she may feel in her position. This phenomenon is especially true in professions that are mostly male, such as the engineering field. For example, a woman named Julia has a blog in which she describes her daily life in Southern California. She is an engineer, and while most of her entries are about her friends and social interests, she also writes about her work experiences in a dominantly male environment. Julia describes negative experiences with how she is perceived by men: “[There] seems to be some confusion about what to do with female coworkers. Do they change in the appropriate dressing room? Do they want to go out to lunch at Hooters? What will they find offensive...[I] somehow seem to be treated as somewhat more delicate than coworkers,

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<sup>32</sup> U. S. Equal Employment Opportunity Commission. (n.d.). Sex-based discrimination. Retrieved Nov. 3, 2005, from <http://www.eeoc.gov/types/sex.html>.

<sup>33</sup> Ibid.

despite fact that [I] can bench press more.”<sup>34</sup> She also discusses how she has used her status as the only woman on her team to her advantage: “[I] can generally work ‘delicate’ thing to advantage by making men open really dangerous chemicals while stand back avoiding nasty fumes.”<sup>35</sup> By reading Julia’s blog, we can see that the issues of women in engineering are complicated by a variety of factors.

Although most women admit that there exists a bias toward women in engineering, some do not see the issue as relevant to their personal experiences. A blogger named Zarrin, a member of her local SWE, describes a situation in which she was asked to help coordinate a presentation to be given to the SWE group. In her correspondence with a professor who was helping with the administrative details, the professor comments that she constantly feels she has to struggle for respect both in academia and engineering, and states that she presumes Zarrin has had the same experiences. Zarrin writes in her blog that she in fact cannot relate to the professor’s experiences and that “the guys aren’t jerks like they were decades ago, they respect me for who I am. I would like to think that part of their respect for me is because I earned that respect...nobody sets me apart because I’m female.”<sup>36</sup> Other women share Zarrin’s opinion that being female is not a detriment to their engineering careers. Depending on the culture of the university programs and organizations a female engineer is associated with, her experiences will vary greatly from one engineer to the next. Recognizing the differences in experiences and assumptions helps us gain a solid understanding of the current state of women in engineering.

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<sup>34</sup> Julia. (2004, November 19). Lake of dreams. Retrieved Nov. 03, 2005, from <http://www.livejournal.com/users/mahkara/27094.html>.

<sup>35</sup> Ibid.

<sup>36</sup> Zarrin. (2004, Dec. 8). A redundant window in my glass house. Retrieved Nov. 04, 2005, from <http://fyerewitch.blogspot.com/2004/12/its-not-same-anymore.html>.

While literature and published research discusses discrimination and other difficulties faced by women in engineering, the reality of working in an engineering position is very complex for most women. Some women experience discrimination and devaluation of their abilities in their jobs, but others do not perceive being female as detrimental in any way to their engineering career. If engineering were extremely oppressive and damaging to women's psyches, there would be no women in the field. Despite the male majority and the instances of disrespect in the workplace, there is something about engineering that keeps women in the field from changing careers. Women stay in engineering because they derive pleasure from their work, because their salary as an engineer provides for the lifestyle they want to leave, because they see their work as fulfilling some social good, or because of any complex combination of factors.<sup>37</sup>

### *Changing the Engineering Culture*

Currently engineering is enveloped in a culture that celebrates hegemonic masculinity. The group dynamics and climate among engineers is often highly sexist and can involve sexist jokes/comments, the exclusion of women in social and professional gatherings, and the creation of group cohesion through alcohol consumption (Lewis & Copeland, 1998).<sup>38</sup> As has been previously noted, the role of the woman in these organizations is often reduced to an auxiliary, unappreciated and unrecognized role involving relational work.<sup>39,40</sup> Instead of changing women to fit into the existing culture of the field, Lewis and Copeland have studied how to change the culture of engineering from within. They suggest that a truly collaborative effort by both men

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<sup>37</sup> Faulkner 2000 b

<sup>38</sup> Lewis, S., & Copeland, J. (1998). We're tired of talking about women: working with men to address the culture of male dominated work and study places. Retrieved Sept. 18, 2005, from University of Adelaide Web site: <http://www.adelaide.edu.au/hr/equity/reports/archives/tired.html>.

<sup>39</sup> Fletcher 1999

<sup>40</sup> Faulkner 2000a

and women is needed in order to affect any real change in the culture of engineering. First, a need for change must be identified, and this area is where men can really be of use. Men are more likely to listen to other men than to women so it is vital to get the most powerful male engineers to see the need for change.<sup>41</sup> And, going back to the pipeline metaphor, a change must also be made at the high school and university level, where classes are often very homogeneous and assignments tend to have a traditional male focus.

### *Conclusion*

The issues of diversity and gender do not exist in a vacuum, and the standards for diversity education in one field may be very different than that in another. In professions that are typically female, such as nursing or elementary education, men who wish to enter the field often experience the same ridicule and discrimination that is similar to that experienced by women entering engineering. In nursing, men leave the profession shortly after graduation from nursing school at a rate almost twice that of female nurses.<sup>42</sup> The need for increased awareness of gender issues in engineering is clearly shown by the extremely low number of women studying engineering and subsequently obtaining jobs in engineering capacities. Women are not predisposed to shy away from engineering and the sciences; rather, a number of societal factors come together to discourage women from MSTE as they go through the “pipeline” from education into the workforce. The women that do make it through engineering programs in college and get jobs in engineering organizations find themselves often not using their technical skills but instead being forced to do the “invisible” relational work that is seen as inherently female.

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<sup>41</sup> Lewis and Copeland 1998

<sup>42</sup> Anonymous. (2002). Male nurses leaving profession faster than females. *Nursing Management*, 33(10), 10-11.

Several professional organizations are committed to increasing the level of diversity in engineering and the sciences through community support, education, research grants and educational scholarships, such as the Society of Women Engineers and Women in Engineering. But in order for engineering to really attract and retain women and underrepresented minorities, there must be a change at the foundation of engineering culture. Through all levels of education and employment, leaders need to first recognize the problems that exist and then open a dialogue about how to change the structure of the system. Very slowly, more women are entering the engineering field, but there is still far more work to be done at all levels and by all engineers to create a truly gender inclusive engineering culture.

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