Bridging the Gender Gap in the Field of Engineering

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Abstract

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Despite efforts to increase female representation in STEM careers, the engineering field has struggled to recruit more women. While women make up half of the undergraduate population, only twenty percent of undergraduate engineering students are female (Yoder, 2017). In this paper, I explore aspects throughout women's education and career that inhibit and discourage them from pursuing engineering. I examine factors in high schools, universities, and the industry that directly or indirectly affect women's interest in STEM subjects. I researched the role of policies in enforcing this underrepresentation and how mentors and people in leadership positions can bridge the gap. I also focus on any societal and career expectations that make it difficult for women in these careers. I examine initiatives that have already been taken to increase female representation within engineering and then analyze how they have been effective and where they can still be improved. Using this research, I will outline a few tangible steps that can be taken by schools of all education levels, but Milligan specifically, in recruiting more women to the STEM field and retaining them in these careers.

According to the US Department of Commerce's "Women in STEM: 2017 Update," women account for half of the college-educated workforce, but only fourteen percent of employed engineers are female (US Department of Commerce, 2017). All aspects of the field reflect this underrepresentation of women, including graduate and undergraduate programs. This issue is prevalent in every school and is even demonstrated at Milligan College. Despite there being a higher percentage of women enrolled at Milligan, there are very few women in the engineering program. Currently in the engineering program, there are sixty-two students, only nine of whom are female, making Milligan's female engineering representation lower than the national average for universities. Women have continued to make advancements in all areas of the workforce; however, engineering has struggled to cover the same ground in increasing female representation. After the initial increase in the 1990s, the percentage of women in the engineering field has begun to plateau, and despite initiatives to encourage more females to pursue a career in engineering, it still remains a male-dominated field. The STEM (science, technology, engineering, and math) discipline thrives when there are diverse groups of people working to solve problems because their different backgrounds and perspectives bring about various new ideas. Homogeneous groups are ineffective, so it is crucial that the engineering field encourages more women to pursue it in order to be comprised of a more diverse group of professionals. The most efficient way to increase female STEM representation is to focus on their education, so that there will be more qualified female engineers. High schools and undergraduate programs need to take steps to foster female representation in the STEM field in order to force the industry to be more intentional about recruiting and retaining women in engineering.

In order to fulfill the increasing need for scientists and engineers, improve and maintain the US's economy, and design innovations that will be beneficial to the nation as a whole, STEM programs need to recruit more women. The US has consistently had a competitive advantage in the world market in terms of innovation and technological advancements. Although the US only comprises 4.28% of the world's population, "the United States continues to lead in science and technology, accounting for 40% of global research and development (R&D) investment and employing a third of the world's scientists and engineers" (Pham & Triantis, 2015, p. 3). STEM careers are growing at a rate that is 6% faster than non-STEM fields and over 6 million STEM jobs need to be filled over the next decade (Pham & Triantis, 2015, p. 12). In order to continue to lead other countries in scientific discovery and meet the need for more engineers, there needs to be a prioritized focus on recruiting more people to the STEM field, and more specifically, recruiting women. Only a diverse workforce will allow engineering to continue to create new designs that benefit everyone. Because "applications for technology and inventions depend upon the experiences and ideas of the designers," the engineering discipline needs to be as diverse as possible (Rosser, 2011, p. 125). The more backgrounds and perspectives that engineering groups have, the more ideas they will be able to generate and they will be able to discover solutions to more problems.

Aside from the economy and competitive nature of engineering, the field also needs more women to remove biases in its research. Because the majority of engineers and scientists are male, there is a tendency to make the test subject of their innovations the average man, and not take into account people of other physiques. This has caused problems in the past with women reacting differently to inventions than men. Because men and women experience differences in cardiovascular disease and the treatment of it, "certain surgical procedures such as angioplasty

and cardiac bypass initially resulted in higher death rates for women" (Rosser, 2011, p. 104). In a similar manner, the automobile industry has made several mistakes in only designing airbags and seatbelts that will protect the average man. In the past there have been problems with airbags killing women and children instead of protecting them, and in 2011, the American Journal of Public Health released findings that women were 47% more likely to acquire severe injuries in car accidents than men (Bose, Segui-Gomez, & Crandall, 2011, p. 2368). With a more diverse group of engineers, it might have been more evident that "a bag that implicitly used the larger male body as a norm would be flawed when applied to smaller individuals, killing, rather than protecting, children and small women" (Rosser, 2011, p. 104). While cars and medical procedures have been modified to fix these issues, had women been involved initially, these mistakes could have been prevented and many people's lives could have been saved. A more diverse group of engineers would ensure a wider range of test subjects and therefore the innovations these engineers create would be sufficient towards everyone, not just men of similar stature. Increasing the percentage of women would eliminate these biases in the designs before they harm society, and it would make the inventions more effective in benefitting everyone.

The most effective method of increasing the number of female engineers is to increase the number of women interested in STEM early on in their education. When more girls participate in STEM throughout high school, more female students will be prepared to major in engineering and in turn, more women will enter this industry. In high school, students begin to choose their own electives and think about future careers. Even before fears of balancing family and career and other concerns that plague the engineering industry are introduced, girls are still less likely than boys to choose engineering and physics/calculus based classes. Less preparation for their engineering classes can cause women in undergraduate programs to have less self-

confidence. This, coupled with other factors that diminish women's confidence such as unwelcoming environments, leads them to leave the engineering discipline (Dell, Verhoeven, Christman, & Garrick, 2017, p. 352). If women are encouraged early on in their education to consider STEM they might prepare themselves accordingly.

Lack of preparation for STEM courses harms women's success in the engineering field and it can prohibit or dissuade them from ever entering the discipline. Many enter college without a strong foundation in STEM. These students are put at a disadvantage because many undergraduate engineering programs prioritize AP math and science classes when admitting students to the program. Without being prepared in high school by taking a variety of STEM classes, it is more difficult for them to be accepted into the engineering program and only the people who were already prone to becoming engineers are given the opportunity. To reduce this bias, high schools should work towards recruiting and encouraging more female students to pursue STEM classes and extracurricular activities. Colleges can also diminish this problem by placing less emphasis on AP STEM courses and standardized math scores, and placing more importance on other factors that are also beneficial for engineers: verbal/written skills, leadership, and social relevance (Beddoes, 2018, p. 1562). First year engineering requirements also prevent people without a foundation in STEM from obtaining an engineering degree. Without completing these requirements their freshmen year, it is almost impossible for students to switch to engineering during their education, making it harder for anyone who was not interested in pursuing engineering when they first started college. Schools can counteract this disadvantage by developing other paths towards an engineering degree and being willing to accommodate for people who are transferring into the engineering discipline (Beddoes, 2018, p. 1569). Many colleges have five-year engineering tracks and these should be made available to

undecided majors or students who are interested in pursuing engineering after being enrolled. Also, if students were encouraged to take more STEM general education courses early on in their college career, transferring into engineering after the first or second semester would be easier and it would motivate more people to do so.

Educators and counselors in secondary education should place an emphasis on certain factors of STEM as to encourage more girls to be interested in and consider a career in engineering. Engineering struggles to recruit women more than some other STEM disciplines, like the health sciences. According to a study conducted at the University of Florida, women are more interested in disciplines where they will be "working to solve major problems and making a difference in people's lives" (Bossart & Bharti, 2017, p. 138). The focus on societal impact attracts more women. Because of this, certain disciplines of engineering where the societal benefit is evident, such as biomedical and environmental, have higher percentages of women. In these fields, underrepresentation among women is not an issue. Environmental engineering awards 50% of its bachelor's degrees to women, whereas more common disciplines, such as mechanical and electrical, are 13-14% female (Yoder, 2017). To draw more girls to engineering classes, educators should concentrate on real-life examples of engineering and how it can be used to benefit society. This focus would attract more girls to take engineering classes and participate in STEM programs, and because there would be an increased interest early on in their education, more girls would then be likely to pursue a career in engineering. These techniques can also aid undergraduate programs in recruiting more women. Every engineering field has the potential to contribute to solving far-reaching societal issues. If other disciplines would emphasize their potential to benefit society and give real-life examples of their specific engineering field, they may be more successful in recruiting more women. Colleges can increase

this emphasis by incorporating it into their introductory courses and class projects. Many introduction to engineering courses address the role of engineers and include projects to give students experience with some of the principles that they will learn about later on in their engineering education. These projects should not just focus on the technical aspect, but also address their importance to society. At Milligan, every freshman engineering project has a humanitarian implication and the freshman introduction to engineering course covers engineering ethics and ensuring that the innovations we create will help others.

Another aspect that dissuades girls from participating in STEM programs is the lack of girls already participating in them. The lack of female engineering role models can make it more difficult for girls to imagine themselves becoming engineers. Also, most of the time, they do not want to be the only girl in the class or the program. For this reason, it is sometimes "more effective to recruit them together in groups" (Milgram, 2011, p. 7). This ensures that girls will not be alone in the STEM programs and it assists them in forming supportive and welcoming communities. When girls know that they will be able to be socially engaged within the STEM field, they will be more receptive to pursuing this as a college major and as a career. Universities have more opportunities to provide prospective female engineering majors with this sense of social belonging. The school should include women in their outreach materials and allow current female students to discuss how they manage to balance their personal life with their studies, a major concern for women considering engineering (Milgram, 2011, p. 6). Also, with upperclassmen and faculty, these universities can provide students with role models and mentorship that they otherwise would not receive.

After recruiting women to engineering programs, colleges and the industry struggle to retain them. Even though the number of women graduating with engineering degrees is rising,

the attrition rate of women in the engineering industry is high. Of engineering bachelor's degrees, 21.3% are awarded to women, while only 14% of practicing engineers are female (Yoder, 2017; US Department of Commerce, 2017). Many female engineers experience a negative, or even hostile, environment, which can make them question their role in the engineering field. Women sometimes face discrimination within their discipline because "the more an individual deviates from the expectation of what a 'professional in the fields looks like' with regard to gender, race, class, age, and other factors, the more others inside and outside the profession will question that individual's professional competence" (Rosser, 2011, p. 46). Women have always been underrepresented in the field of engineering, so there can be beliefs that women are less capable of being successful in engineering. This bias can also lead to micro-inequities, small, repeated instances where people are overlooked or perceived as different, from leaders and other professionals.

Overtime, these micro-inequities erode self-confidence and can make women feel like they are unfit to be in engineering. This can lead them to develop a poor engineering identity. Engineering identities focus on whether people consider themselves to be, or have the qualities needed to be, an engineer and they greatly affect a student's and professional's willingness to persist through the challenges presented by engineering. The identity is commonly measured through an individual's beliefs about their performance and competence, their interest in the subjects, and whether or not they feel they are given recognition for their accomplishments (Verdin, Godwin, Kirn, Benson, & Potvin, 2018, p. 49). The role of departmental environment and engineering identities are connected and are significant determining factors of whether the engineering department will retain many of its female students and employees. The lack of self-confidence becomes an issue too because women are more likely to attribute failures to personal

shortcomings, and successes to external factors, whereas men are more likely to do the opposite (Rosser, 2011, p. 24). When men make mistakes, they are more likely to believe that it was just a coincidence and move on, however, women are more likely to believe that the mistake reflects a flaw in themselves and their career as an engineer. All of these factors taken together (people questioning their competence, micro-inequities from leaders, and the tendency to blame themselves for failures), damage female engineers' self-esteem and can lead them to eventually leaving the field.

One of the best ways to create a more supportive and welcoming environment is to implement social support systems (Rincón & George-Jackson, 2016, p. 745). At the undergraduate level these can include peer mentorship, living-learning communities, or clubs/organizations within the department. In the industry, companies should create opportunities for women to build informal networks and connections. The increased support systems allow women to create a sense of belonging within their field and form connections with their peers and leaders where they may otherwise have been excluded. Leaders within these fields can also have a significant effect on the departmental environment. Faculty in undergraduate programs can provide women with research and internship opportunities, which build their confidence, contribute to a stronger engineering identity, and help them gain respect from their peers and other faculty (Rincón & George-Jackson, 2016, p. 746). Professors can also provide mentorship that is typically unavailable to female students because of the lack of women in engineering. By being intentional about mentoring and retaining women, the engineering program will thrive and become more diverse. (Beddoes, 2018, p. 1570). Leaders in the profession also need to take the initiative in supporting and encouraging women to continue in their careers. Diversity needs to be a priority at the company/university and leaders need to present diversity as a competitive

advantage in order to encourage more people to support hiring and retaining more women and minorities (Guy, 2018, p. 53). Undergraduate programs and engineering firms will design a broader range of solutions with more women, so it is in the best interest of leaders at these institutions to lead the way in mentorship and retaining underrepresented groups. Women can also take initiative in building a community by seeking out opportunities within their company or with other organizations, such as the Society of Women Engineers (SWE), that will support them whenever they are discouraged from continuing in their career.

The primary concern raised when it comes to the lack of women in the engineering profession is the struggle to balance family and career. Engineering is a demanding and challenging field, and it can be difficult to keep up with the fast-paced speed of it all, while also raising a family, especially when there are few policies set in place to aid in balancing the two. Some family-friendly policies that would allow more mothers to continue to be engineers include parental leave, on-site childcare, and stopping the tenure clock (extending the deadline for tenure so that having children does not conflict with that). These policies would ease the discord between family and career; however, they are not the only modifications that need to be made. Several countries outside of the US implement these policies, yet still have the problem of women being underrepresented in engineering. Sometimes these policies can create increased expectations of these women. For example, stopping the tenure clock technically gives these women additional time to complete the requirements and their bosses may expect an extra year's worth of work, even though they spent their time caring for their baby. These higher expectations reduce the effectiveness of the family-friendly policies and once again make it difficult for women to balance family and career. To ease these conflicting priorities, companies should instill family-friendly policies in addition to reducing the expectations of men and women during

their parental leaves (Rosser, 2011, p. 61). An example of a company that has instilled some of these policies is PAE, an engineering consultant firm with locations in Seattle, Portland, and San Francisco. Some of their work-life balance policies include six week paid parental leave (twice as long as the US median), flexible hours and the opportunity to telecommute from home once a week, mentorship for new employees to aid career advancement, and planned social activities to increase community within the company (PAE, n.d.a; WorldatWork & Mercer, 2017, p. 5). These programs combat several of the aspects of engineering that have dissuaded women from pursuing these careers. PAE has succeeded in increasing female representation and as of this past year, four out of nine of the management-level promotions were women (PAE, 2018b). These family friendly policies are not implemented in very many places, but at the few firms where they have been, these policies are effective in increasing female representation and therefore should be considered by other companies as well.

Some may be opposed to evaluating and modifying these aspects of women's education and career because they believe that it's not causing the gender gap. They would argue that the lack of women in the engineering field is the result of personal choice or a biological difference between men and women. While most women who choose a career path other than engineering do so out of their own choice, some are never given the opportunity or introduced to the field. As these barriers have been reduced, the percentage of women in STEM has continued to increase and the other fields of STEM (science, technology, and math) have seen much higher rates of success in terms of female integration. As biases in engineering specifically have been addressed, the number of female engineers has risen, proving that there are systemic issues that are aiding the gender gap. Rosser also compares the issue of choice versus discrimination to women not being given equal access to sports until Title IX. She claims that, "in my day, most

girls who ‘chose’ not to play sports really believed that they preferred other activities” (Rosser, 2011, p. 8). Once the biases are removed, more women will choose engineering, just like they have begun to choose other careers that were once male-dominated. Another opposition is that men are biologically predisposed to be more successful in engineering. Research on gender differences has found that there are far more similarities between men and women than there are differences, and that in countries with greater gender equality, the differences are even narrower (Johnson, 2017). This suggests that the gap in the engineering field is primarily a social one, not a biological one. The social systems that are currently in place need to be reevaluated in order to ensure that women are not being prohibited or discouraged from pursuing engineering.

The underrepresentation of women is also prevalent in Milligan’s engineering program and the steps listed to improve it at the undergraduate level could be beneficial. Milligan’s female engineering percentages are lower than the national average, but they are similar to the statistics for mechanical and electrical engineering, the only two disciplines currently offered. Also, while Milligan’s percentage of women in the engineering field is fairly low, it continues to increase every year. When the engineering program first started two years ago, there were only two female students, and now there are a total of nine. Each year the program has existed the number of women has doubled. Some of the suggestions listed are already being implemented at Milligan. The school’s Christian focus affects how engineering is taught and stresses the social relevance of engineering and how it can be used to help other people. In the freshman year, all engineering students are required to take an introductory course which covers what engineers do and includes design projects where students can get hands-on experience their first year. All of the projects have a humanitarian focus designed to serve others. Milligan is also in the process of founding a Society of Women Engineers chapter in order to foster community with the women in

the program and they have already hosted “Women in Engineering” preview days to intentionally enroll more women and recruit them in groups as to feel less isolated. Despite all of these steps that Milligan has already taken, there is still room for improvement. The engineering program is difficult to transfer into after first semester. Accommodating for people who switch from other majors and establishing a five-year plan in the course catalog would allow people who were not previously introduced to engineering to pursue a career in this field. In addition, advertising the Introduction to Engineering course not just as a first semester engineering class, but also as a useful course for undecided majors, would help introduce engineering to people who are unsure of majors and possibly recruit more people who did not receive a good STEM foundation in high school.

As the US continues to reduce gender biases and lead the world in technological innovation, the need for more women in engineering becomes increasingly evident. There are several modifications that can be made within high schools, universities, and the industry that would help diminish discrimination against women and encourage more to pursue engineering. High schools must take steps to ensure that women are prepared to be able to enter an undergraduate engineering program if they choose to. Universities and companies should become progressively more dedicated to recruiting and retaining more women. If these policies and emphases are all implemented together, each level of education and career would benefit from it- the industry receiving more qualified female engineers and colleges and high schools would have more role models for women considering STEM to look up to. These systems that prevent women from pursuing careers in engineering need to be evaluated so that the engineering discipline can be more diverse, produce more ideas and designs, and benefit the wide array of people that their inventions will serve.

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