



Impact of Humanitarianism on Female Student Participation in Engineering

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Abstract

In 2015, 57% of all undergraduate degrees were awarded to women, but in engineering that number was only 19.9%. Despite efforts to attract and retain women to STEM majors, that number has been essentially stagnant since 2006. Some suggest that this inactivity may in part be due to the way women and female students perceive engineering.

Research has shown that one of the reasons women may identify a preference for medicine and the biological sciences over engineering, may be due to perceptions of engineering being less 'people-oriented' and having less value to society in general. Other research indicates that women tend to value altruism and social rewards higher than their male peers. Findings show that increased demonstration of the societal role of engineering can help increase participation of female students.

Existing data gives reason to believe that enrollment and retention of female students at X University may be linked to certain perceptions about a particular major or profession. Perceptions of a major being human-centric and enabling an individual to make a difference were shown to be significant factors among those identified in a research study. Literature will be presented to show the connection between humanitarian efforts undertaken in an engineering context, and the impact that it has had on female student participation. This paper will attempt to show the trends of female enrollment and retention among various majors at X University, and compare them to programs, organizations and projects which have a humanitarian aspect.

It is important that engineering colleges across the nation make a concerted effort to invest in promoting the humanitarian aspects of engineering. Communication focusing on reminding students that the STEM majors can contribute to society can be a valuable tool to help recruit and retain female students.

Introduction

Research shows that diverse groups can have a positive impact on creativity, innovation, decision making and overall productivity. This is true in a variety of different fields - from diverse scientific teams producing better quality research [1,2], to diverse juries being fairer than those of less varied demographics [3]. In the case of gender diversity, there is extensive literature on the potential benefits that a more equal representation can have in an organization. In business, companies with a more equal representation among genders in the e-suite [4, 5] or in top leadership/management roles [6] see on average greater financial gains. Gender diversity in the workspace can also foster the adoption of gender sensitive design practices, as including women in the design iteration process has been found to lead to products being safer and of higher quality [7]. There have also been many examples where a lack of gender diversity in an organization leads to discrimination, further exacerbating potential remediation [6, 7]. When working in a diverse team, people may assume that those who are different from them have differing perspectives, and work harder to achieve consensus, expend a greater amount of cognitive energy and positively change behavior [3].

On average, women constitute about 50% of the student population in universities across the US, but constitute only about 20% of the engineering students. This disparity has manifested itself in several areas, and spurred efforts to boost female and other under-represented minority (URM) participation in engineering. Currently the percent of women working in science and engineering occupations is currently at about 30% [8]. Once employed women tend to leave the engineering field in larger numbers than men. A national survey by the Society of Women engineers examining why women leave the field found that 47% of women participants indicated that the reason for leaving engineering was because of 'more interesting work in another field' compared to just 33 percent of men participants [8] The most identified reason for men to leave engineering was for 'better opportunities or salaries' [8].

There are many potential reasons as to why engineering has trouble attracting and retaining female students, and similarly why engineering professions seem to experience larger attrition of women. One study suggests that an unwelcoming climate that women experience in engineering colleges and professions as a potential primary reason [9]. This paper will look to explore the hypothesis that female students' perception of engineering majors might also be a contributing factor. Specifically, perceptions of engineering not being people oriented enough, or that it does not help humanity as a principal factor for attrition. This paper will also examine possible ways of how incorporating a human component and highlighting humanitarian aspects could help increase the participation of female students in engineering.

Women and Humanitarian Engineering

The effects of engineering can be quite significant; from simple machines to current nanotechnology, engineering has the potential to change one's understanding on world. The opportunity to contribute and benefit from the effects of engineering is not always equitable. People who are typically underserved in society, including those of lower socio-economic status, people with disabilities, and those who live in developing countries may not have access to the same benefits as selected populations.

Humanitarian Engineering is an area which aims to promote human welfare through the creation, invention and modification of appropriate technologies. One of the specific goals is to address needs of people who have been largely ignored by the engineering community [12]. Over the last decade, humanitarian engineering programs and organizations have emerged in large numbers in the US. Additionally, humanitarian engineering programs typically tend to attract larger number of female students than mainstream engineering programs. For example, a study at the Colorado School of mines found that the percent of female engineering students who were participating in capstone projects that had a humanitarian aspect were significantly larger than those participating in projects without one [13]. The

organization Engineers Without Borders (EWB) works on development project in developing countries, and reports that 43% of all its members are women [14]. Between 2004 and 2007, at Colorado University in Boulder, about half of the 190 graduate students who took courses through the EDC program were women [14].

There is a gap in the literature that makes reaching statistically significant conclusions difficult. A first step to generating such data will be to examine the situation at an existing setting for information on a starting point for further study. The next section covers information about engineering programs and courses which are related to humanitarian engineering at X University.

Participation in Engineering - The numbers

At X university in 2018, women constituted 23.4% of the overall engineering student population. This number varied significantly depending on the engineering major. Figure 1 shows the variation across 15 engineering majors between 2012 and 2017. In addition, the total percent for engineering and for the Humanitarian Engineering Scholars program is also shown. Figure 1 shows that majors with above average female enrollment percentages are Environmental, Industrial Systems, Material Science and Biomedical Engineering. The Humanitarian Engineering Scholars (HES) program is centered around the theme of humanitarian engineering, shows consistent higher than average female participation, with over 50% in 2016. The majors of Computer Science, Electrical and Computer, Aeronautical, Mechanical and Welding have below average participation. A case can be made that the majors in which there seems to be a more direct connection to people or are considered to be societally impactful are the ones that had the most female student participation.

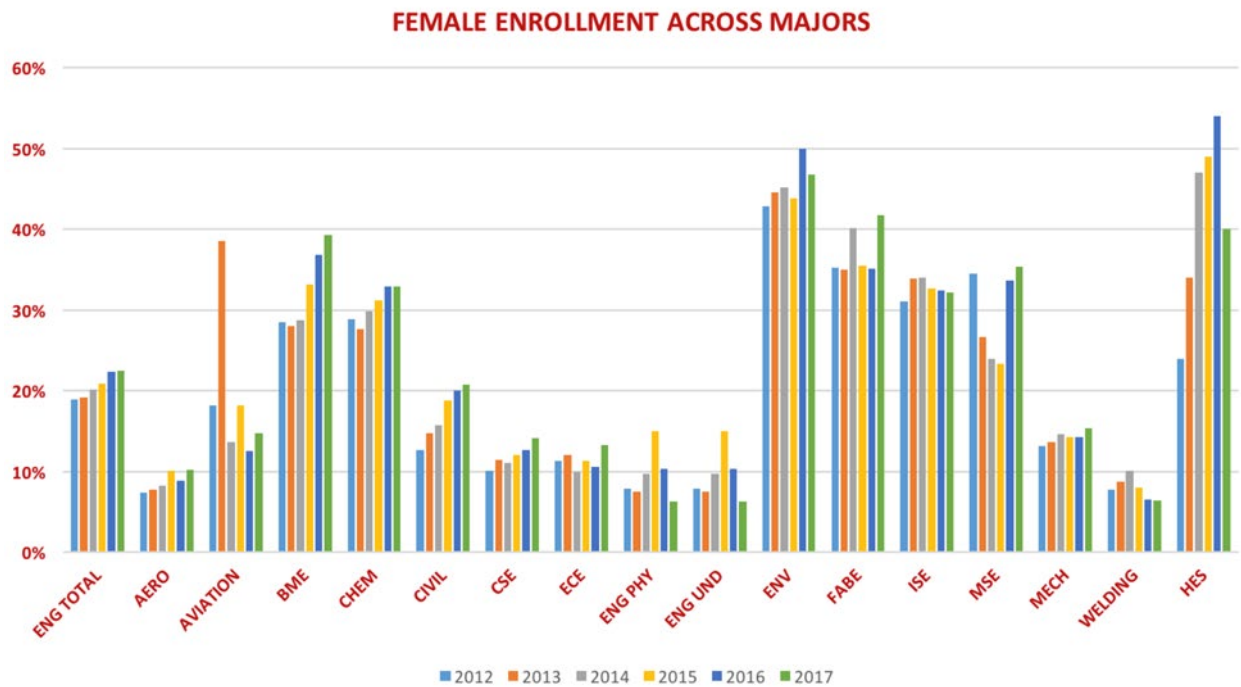


Figure 1 Female enrollment percentages by major

International and Local Engineering Service Learning

Engineering service learning trips are offered every year to students during the spring break, the summer and during winter break. These trips typically consist of students from a variety of engineering majors, as well as some from outside the college of engineering. In addition to providing the participating students an opportunity to use their technical skills for social good, the students also get the chance to learn about the people, the culture and the history of the place that they are visiting. These trips usually involve an in-country partner who work with underserved populations trying to address an unmet need. While most of the trips are out of country trips, there are a few in-country or in-state. Table 1 shows the student enrollment in these trips between 2015 and 2019. Of the students (N=88) who participated in service learning courses, 53.4% (47) were female. The number also show that in 5 of the 7 courses female students outnumber male students.

	Male	Female
Summer 19 - Guatemala Service Learning	4	6
Spring 19 - Local Service Learning	3	5
Autumn 17 - Ghana Service Learning	4	10
Spring 17 - Honduras Service Learning	6	8
Autumn 16 - Ghana Service Learning	11	6
Summer 16 - Guatemala Service Learning	6	5
Summer 15 - Guatemala Service Learning	6	8

Humanitarian engineering minor and courses

The Humanitarian engineering minor was started at X University in the year 2015. The students who participate in the program take 15 curriculum hours of core humanitarian engineering courses, courses covering human welfare and participate in humanitarian engineering project work. The minor currently has 56 students in total and over 64% of whom are women.

Humanitarian Engineering (ENGR 5050) is a course offered at the X university which introduces topics of poverty, social justice, sustainability and the creation of technologies that can benefit people. Between 2014 and 2016, the course was offered three times and had a total of 51 female students participate. This accounted for 35% of the total student participation in this course.

Programs and Student organizations

Two communities of engineering students are considered here. The first is a University scholars program aimed at engineering students with a passion for helping others and an engineering student organization which focusses on creating products and solutions for underserved communities.

Humanitarian Engineering Scholars

The Humanitarian Engineering Scholars Program (HES) is one of 17 scholars' programs at X University. The programs are centered around a particular theme and provide students the opportunity to participate in theme related activities. Students from all scholars programs participate in community service, students in HES are particularly exposed to how engineers from different disciplines can make a difference in their community. During weekly or bi-weekly seminars, students are introduced to humanitarian engineering and projects that have had an impact around the world. They hear from engineers and researchers who have been involved in humanitarian engineering projects and learn of their experiences in the program. Students in the HES program are also tend to be involved with other humanitarian engineering student organizations on campus, such as Engineers Without Borders, Engineers for Community Service, and Design for 90.

In the five years between 2012 and 2017, on average 40.14% of the 634 enrolled HES students were female. The numbers were consistently higher than the average enrollment numbers for the College of Engineering during the same period.

Design for 90 - In February of 2015, a new student organization called Design for 90 was started at the X University. The aim of Design for 90, was to design for the 'other 90%', the bottom 90% of the world population left out of the benefits of human centric design [citation]. This demographic includes underserved populations, such as people with disabilities, the homeless, systemic inequities, and so forth.

The mission of the group is as follows:

1. To work with community partners to identify needs and to develop solutions to those problems.
2. To serve as an inclusive practical learning community to help students develop and use the skills acquired in the classroom to serve typically underserved populations in the Central Ohio region and beyond.
3. To enable students to enhance their leadership, team working and communication skills.

The operating mechanism for the organization is shown in Figure 2.

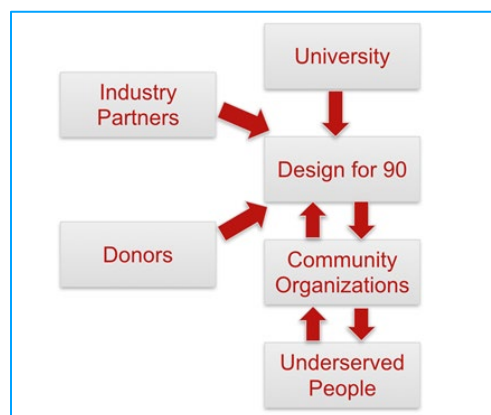


Figure 2 Design for 90 Structure

The 2017 - 2018 school year was the first complete year for which reliable data was available. A total of 48 students attended Design for 90 meetings and participated in project teams for the year. When considering students by year, there were 14 first years, 10 second years, 10 third years, 10 fourth years and 1 fifth year. During this year, the group had exactly a 50% participation of female students from a variety of engineering majors and a few non-engineering majors.

Discussion and Future Work

An overview of the demographic participation in engineering at X University shows that women still languish behind men in overall engineering enrollment. When considering majors which are perceived as having greater potential to have an impact on humanity, there tends to have larger female student enrollment numbers. This can also be observed in courses, programs and organizations that have a connection to humanitarianism at X University. Data from University X gives reason to look into the correlation between humanitarianism and female participation. Institutions can play a significant role in recruiting and retaining women in Engineering. The methods suggested below are not all encompassing but just a start in the right direction.

Outreach

Majors with reported perceptions of low humanitarian impact could highlight the contributions that the particular area of study have had on humanity. During the recruitment stage, showcasing the humanitarian potential of the major could also potentially help boost female enrollment. This can be done through introductory engineering courses before students declare majors, through exposure to real world projects and in the field.

Incorporation of HE projects in the classroom

Linking coursework to potential applications may be one way to continue to cultivate the desired perceptions. Humanitarian engineering components could be included as part of the naturally occurring course dialogue. For example, a class dealing with micro controllers and sensors can have a final project situates the project for monitoring CO₂ in the atmosphere. A structures class could include a project that designs a building taking into account the restricted resources of a developing country.

Humanitarian engineering focused programs and organizations

Programs such as the HES and organizations such as Design for 90 can be further supported by the university. Humanitarian Engineering projects are often inter-disciplinary, which give students opportunities to work on projects which may not be directly related to their major.

Additional Perception Data

A more detailed study about student perception about different majors before enrollment, before graduation and after graduation would shed light on student motivations. It is also important to acknowledge that there are likely other factors that influence female student retention in engineering. For example, the unwelcoming climate that women face in the engineering through micro-aggression and implicit bias is a factor. A more thorough investigation student perception of different majors is needed to show correlation between perceptions of majors at the current setting.

Note

1. It's also important to note that the numbers listed above assume binary gender options. The numbers and results can vary slightly, keeping in mind that some of the numbers might change when gender non binary students are included.

2. There might be some overlap with these numbers. So for example, a small number of students might be a part of the HES, have taken the ENGR 5050 course and be currently part of the minor.

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