A Discussion of the Barriers Present to Female Engineering Students

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Abstract

Diversity in engineering has been a focus in research for decades. Recruitment efforts for women in engineering have had limited success in recent years, and studies have shown that the percentage of women enrolling in engineering fields began to decline in the early 2000s. In this study, we investigated the stories of nine different female engineering students on their experiences in engineering. Using semi-structured interviews, we gathered information on what factors impacted these students' decisions to major in engineering. Our research question in this paper is *What external factors do female engineering students cite as barriers to female entry into the field?* We found in our investigation that stereotype threat embodied within peer expectations and societal pressures form a barrier for women in engineering. The women in our study cited specific instances in their own lives that emulate the need for better recruitment practices as well as diversity education.

Keywords

Gender, diversity, qualitative research

Introduction

Diversity in engineering has been a cause for concern for decades, and in response to these concerns, the National Institute of Education called for researchers to write papers on women in STEM in 1977 (Eccles, 2011). At that point in time, the enrollment rate of women in engineering was approximately 1%. Today the female enrollment rate in engineering is close to 20%, but the National Science Foundation and independent researchers found that in the early 2000s the percentage of women enrolling in engineering began to decline (Cohen & Deterding, 2009; Grose, 2006; "Women, Minorities, and Persons with Disabilities in Science and Engineering 2015," 2015). In response, national societies, such as the American Society for Engineering Education, have created actions on diversity. Researchers on women in engineering have discovered a plethora of motivational struggles from lower self-efficacy to stereotype threat (Beasley, 2012; Holloway, Reed, Imbrie, & Reid, 2014). While researchers understand many of the barriers present to women, there has been little research into how women react to these barriers.

Our paper is a portion of a larger investigation into the motivations for women to enter into engineering programs. We used a semi-structured interview to gather rich thick descriptions of the experiences nine women in engineering undergraduate degrees. In this paper, we will mainly discuss the participants' opinions on the hardest part of being a female engineer. The question guiding this investigation was:

What external factors do female engineering students cite as barriers to female entry into the field?

Methods

We created a semi-structured interview protocol that explored the experiences of the participants from their first experiences with engineering to the struggles that they currently face. The interviews lasted from 15-25 minutes depending on the willingness of the participant to discuss their experiences. The semi-structured interview was developed as part of a course for qualitative research and was evaluated by a professor who utilizes and instructs on qualitative research methods.

Participants for this study were recruited through the Mississippi State University's Society of Women Engineers (SWE) chapter. An email containing information on the study as well as a link to a sign-up page was sent to the chapter president who then forwarded it to their members. SWE was used as a recruitment method as the chapter contains women from every engineering discipline on campus. We had nine volunteers for this study who together represented every engineering department on the Mississippi State University campus.

The interviews were conducted by a female engineering graduate student from Mississippi State University in a private room. The interviews were recorded in their entirety and transcribed using MaxQDA, and in this investigation, we will be concentrating on what the participants cited as barriers for themselves and others.

Participants

We had nine participants in this study. Pseudonyms have been assigned to the participants to ensure anonymity.

Table 1 Participants

Pseudonyms	Major
Anna	Aerospace Engineering
Beth	Biomedical Engineering
Christy	Chemical Engineering
Cathy	Civil and Environmental Engineering
Cindy	Computer Science Engineering
Eliza	Electrical Engineering
Ingrid	Industrial Engineering
Margie	Mechanical Engineering
Meg	Mechanical Engineering

Data Analysis

Two female graduate students in engineering coded the transcribed interviews using open-coding methods as outlined by Strauss (Strauss, 1998). They coded the interviews separately from each other in stages in order to form a cohesive code book that was then applied to all nine interviews. The first round of coding was done on three of the interviews, and the coders assigned a key word to every sentence of the interviews. They then met to discuss their most common codes and formulated a semi-structured code book that was applied to the next three interviews. The coders then used the codes from the second set of interviews to formulate the final codebook which they then applied to all nine interviews and evaluated together to check for any personal bias's or misunderstandings of the codes. In this paper, we will be discussing the codes that pertain to external barriers that influence women in engineering.

Results

The two biggest external threats to female entry in engineering cited by the participants were stereotypes and a lack of belonging. Prior research has often discussed these issues for women in engineering, but these issues have rarely been investigated using qualitative methods. Our research found that not only are these issues prevalent but that female engineers often have specific examples of prejudice against them.

Eight of the nine participants cited negative stereotypes as a barrier for women in engineering. Women are often stereotyped as not being talented at math or science, and these stereotypes appeared explicitly within the interviews (Beasley, 2012; National Academies & National Academies, 2008). Eliza openly acknowledged that men are stereotyped as being better at STEM fields.

> *"it's got a lot to do with stereotypes because you know a lot a like 'guys are supposed to be smarter in math' and some of them are but it's weird because we're not that bad actually sometimes we're smarter than them" -Eliza*

Cathy, Cindy, and Ann all discussed how negative stereotypes about women in engineering affected others' opinions on their abilities to perform tasks.

> *"People are surprised when they see that I'm doing engineering for the fact that I'm a girl. And then they kinda acted like there's something that's going to hinder me from doing my job right just because I'm a female." -Cathy*

> *"A lot of guys have the perception that they know more than me" -Cindy*

> *"Even some of my fellow students, they don't want to listen to what I have to say and they blatantly told me it's because I'm a woman that they don't think that I know as much as they do." -Ann*

Negative stereotypes about women in engineering directly impact engineering undergraduate females. The perception that women are not as talented in math and science cause their peers to treat them differently and appear to directly impact their own self-efficacy. In order to mediate the negative affect of these stereotypes, some of these participants talked about using negative

stereotypes as a motivator to perform better. Christy discussed how she uses external pressures to better prepare herself for classes.

> *"So I'm on my A game every single day I walk into that building. Making sure that I know what I have to do that day." -Christy*

It is important for professors and researchers to acknowledge that many women in undergraduate engineering courses face specific instances of prejudice due to stereotypes. In the future, more research should be done to discover how best to negate the effects done by stereotype threat.

Lack of belonging was another major issue discussed by the participants in this study. Seven of our participants discussed how the lack of female community affects them as engineers. Prior research has found that lacking community can impact female retention rates and lower female satisfaction in engineering (Amelink & Creamer, 2010). Beth and Meg both discussed how being a minority in engineering affects them.

> *"And then there's just so many guys around you. It's so, it's so hard sometimes you know" -Beth*

> *"But it is - it can be intimidating walking to walk into a room and there's a lot of other guys there and like no girls." -Meg*

The intimidation of being different from the norm appeared in these interviews. Ingrid, Eliza, and Cindy all proposed different ways of counteracting this barrier.

> *"But I also just think like for girls like it is a male dominated field and so I think like once more girls start going into engineering more girls are going to be like 'oh, I can do this'" -Ingrid*

> *"I think we should work on retention, like the only girls who show up, don't stay, and I don't like that." -Eliza*

> *"You know there's just not a whole lot of [girls]... I feel like girls need that type of role model in their life or needs someone to tell them that they are going to be good" -Cindy*

Ingrid believed that the lack of females in engineering causes women to have lower self-efficacy in the field and impacts female enrollment rate; thus, she proposed that more recruitment programs would rectify this barrier for women. Eliza, on the other hand, stated that she believes that researchers and practitioners should focus on better retention programs in order to maintain the population that does enroll. Cindy personally believed in the need for stronger role models. All three of these ideas have been proposed by researchers as solutions for women in engineering, but the efficacy of each method needs to be further investigated.

Conclusion

Our qualitative analysis allowed us a deeper perspective into the barriers that women in engineering face and how it effects them. Negative stereotypes and lacking community both greatly impact female engineering students. While researchers have known about these barriers,

we were not aware of how they impact female engineers at a personal basis and how women navigate these barriers. Our investigation allowed us to collect stories from female engineering students on their experiences.

Negative stereotypes appeared as a barrier for the majority of the women in this study, but some of the women also used these stereotypes as a form of motivation to out-perform their peers. Navigating this barrier, however, does seem to have consequences in terms of women's self-efficacy and stress levels. Further investigations should be done to analyze the true effects of stereotype threat and how best to negate them.

Lack of community was another common barrier that the participants themselves proposed solutions for. The participants discussed more effective recruitment methods, stronger role models, and better attempts at retention of women in engineering. Future work should be done to see which of these methods is the most effective at increasing the female engineering population.

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