

The Motivations and Obstructions for Female Engineers

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Abstract - Engineering educators have been researching diversity within engineering for decades. One popular area of research is females in engineering due to their historically low enrollment. Engineering currently has an enrollment rate of approximately 20% female and some research in the early 2000s showed enrollment rates decreasing. While researchers have examined quantitatively why women choose engineering, there has been less qualitative research to fully examine the phenomena. Using a critical theory paradigm, our work investigates three different female engineering students' perspectives on why they entered engineering. We explored how these females chose engineering through semi-structured interviews. The research questions driving our work were 1) *What factors do female undergraduate engineering majors assert as the strongest influences in their major choice?* 2) *What barriers do female engineers perceive in their major choice?* Our work is a first step into understanding how these three female engineers decided to major in engineering and what they perceived as the most influential factors their major choice. Some motivational studies have been done on female major choice, but our work is an attempt to engage female engineers in conversation and provide rich, thick descriptions of how they've experienced the engineering pipeline.

INTRODUCTION

The lack of females in engineering has been a concern for many years, and efforts to increase female enrollment rates have only been mildly successful. The unequal enrollment rate of women in engineering indicates a need to better understand how to increase female enrollment. The 1970's had an enrollment rate of female engineers around 1% which has since increased to approximately 20%, but researchers have found that enrollment rates for females in engineering began decreasing in the early 2000s [1, 2]. Researchers have concluded that females lack neither the ability nor aptitude to enter engineering. Instead, the issue appears to be related to their formative years: at some point, young females lose interest in STEM fields and do not enroll in engineering degree programs. For the females that do enroll in engineering, Cohen and Deterding's [1] evidence showed that they are no less successful than their male counterparts in progressing through an engineering degree program. This

evidence suggests that if we can increase the number of females enrolling in engineering, it is likely that we would increase the numbers of females graduating with an engineering degree. Therefore, part of the solution for increasing the number of females graduating is to create more effective recruitment programs.

Multiple researchers have contributed to the discussion of low female enrollment in engineering and why effective interventions need to occur. Su [3] discussed the need for female engineers from three different perspectives: practical, economical, and sociological. The recruitment of females is practical because they bring diverse approaches to problems. It is economical because the current need for engineers is greatly exceeding our current matriculation rates, and bringing females into engineering fills a sociological need because women have been historically dissuaded from engineering. The female students who do enter engineering often discuss the "chilly climate" of the field, which could contribute to the different enrollment rates of males and females [4]. It has also been noted that females who go into engineering usually have higher high school metrics (i.e. GPA, class rank, etc.) than males and achieve at higher rates, yet they enroll at lower rates and have lower self-efficacy from the beginning of their engineering careers than their male counterparts [5]. This is likely due in part to the sociological and historical pressures that forms pre-conceived ideas about female engineers' abilities.

The lower enrollment rate of female engineers could also be due to a lack of female community within engineering. Amelink and Creamer showed that females, when they do leave engineering, frequently leave due to a lack of belonging, which leads to the question of how to increase female recruitment and retention when one of the most cited problems is lack of community [6]. Researchers have been attempting to solve the lack of community for female engineers in a variety of manners. Some research has shown that an early introduction to engineering may increase enrollment rates for women [7], and by increasing enrollment rates, the community issue for female engineers will eventually solve itself. Other researchers have attempted to solve the community issue by creating computer based models to counteract stereotype threat [8] and by hosting interventions to help create more stable engineering identities for female engineering students [9].

Previous researchers have conducted semi-structured interviews in case studies in order to define expectancy valued motivations for persisters within engineering, but the research did not investigate females with the intention of developing the engineering pipeline for female engineering students [10]. Other researchers have used focus groups combined with surveys to determine how gender can affect satisfaction within engineering [6]. The information these researchers have constructed depicts more of the motivations for females within engineering, but it does not explore previous motivations and obstructions. With this information, it is clear that researchers are aware of what issues female engineers face, but we do not fully understand how many of these barriers females are aware of and how female engineers navigate around these obstructions.

As a first step towards understanding the engineering pipeline for women, we investigated factors that influenced three female engineers in their choice of major and what barriers they perceived for themselves and other female engineers. We interviewed three female engineers in different majors to collect rich thick descriptions of their experiences as female engineers in both the selection of their major and the barriers they have encountered. The research questions driving this work are: 1) *What factors do female undergraduate engineering majors assert as the strongest influences in their major choice?* 2) *What barriers do female engineers perceive in their major choice?*

METHODS

Our study was submitted to the IRB and granted an exempt status under Qualifying Exempt Category: 45 CFR 46.101(b)(2). Our research used the critical theory paradigm meaning that the researchers and the subjects engaged in more of a dialogic manner where both contribute to the conversation [11, 12]. Knowing this we used a semi-structured format, we interviewed female engineers at a large research-focused university in the southeast United States. Recruitment occurred through the Society of Women Engineers (SWE) via email, and individuals volunteered via a survey. SWE was used for recruitment as it allowed access to females in a variety of engineering majors. Using SWE limited the sample field to females who are more involved in campus and engineering, but the choice to use SWE was made because of their ability to contact female engineers across all departments. Interviews were conducted in a private setting. In this paper we discuss the results of three different interviews. The women interviewed were all from different engineering majors; two were seniors, and one was a freshman.

I. Instrument

We developed a semi-structured interview protocol with open-ended questions to allow participants to expand their answers based on their experiences. Demographic information such as year in school and engineering major was also collected. The interviews were recorded using a laptop, and the interviewer attempted to make the interviews as casual as possible so as to collect more candid and genuine responses. There were overall guiding questions, but the semi-structured format of the interview allowed it to become more conversational and allowed the participants to reveal more details than they may have revealed in a formal interview setting.

II. Procedures

The semi-structured interview averaged 10-15 minutes in length. Interviews were transcribed and coded using open coding and thematic analysis in MaxQDA by two researchers who then discussed the codes to eventually form themes. The interview consisted of eight base questions with the option for the interviewer to ask follow-up questions, if necessary. The following questions comprised the basic interview:

- 1) *What is your major and year in school?*
- 2) *When was the first time you heard of engineering?*
- 3) *Why do you think you chose engineering?*
- 4) *Why do you think you chose your major in particular?*
- 5) *Why do you think girls lose interest in engineering in their formative years?*
- 6) *What is the hardest part of being a female engineer?*
- 7) *What do you like about being a female engineer?*
- 8) *Is there anything that you believe I missed or anything you would like to add?*

III. Validity

For validation of the research, we used peer review, audit trail, and attention to sampling methods. For peer review we had researchers code each interview separately and compared the themes that were developed. Detailed notes on our coding process were recorded as a part of our analysis in order to maintain an audit trail for confirmability that we have recorded what is true. We used rich thick descriptions of the data we have collected to satisfy recurrent patterning and transferability to other engineering females. The interviews were also conducted in a semi-structured pattern to allow for more honest and open answers in order to saturate the data. The last question will also allow the participants to discuss anything they feel that we may have missed in our research and allow for member checking.

RESULTS

I. Question 1: What is your major and year in school?

The first two interviewees were seniors in engineering. One was in Chemical Engineering and the other was in Computer Engineering. The third participant was a freshman from Civil and Environmental Engineering. The seniors who were interviewed were further from when they made their major choice thus they struggled a bit more with identifying specifically why they chose their major, but they were more familiar with the barriers present for women within engineering itself and were more forthcoming with examples of exclusion and feeling different. The freshman engineer was closer to her major choice, but she had been less exposed to some of the issues that female engineering students face.

II. Question 2: When did you first hear of engineering?

“A lot of it was primarily dominated by my parents”

“My parents pushed me towards engineering”

“My family is very industrial... my brother....he is doing mechanical engineering”

Every participant that was interviewed in this project had family involved in engineering and expressed having early exposure to the field. The participant from Computer Engineering (CPE) cited not being asked what she would be when grown but rather “what kind of engineer do you want to be.” The CPE participant also discussed how she would encounter younger girls interested in engineering programs and how they would have confidence issues. The participant cited that having her mother, who is an engineer, as a role model helped guide her into engineering and establish a strong self-efficacy.

The participant from Chemical Engineering (CHE) discussed how both of her parents were engineers and encouraged her to enter the engineering field from a young age. Early exposure to engineering occurred for the Civil and Environmental Engineering (CEE) participant as well. She discussed how her family worked in an area similar to engineering and that her older brother is an engineering student as well. Being introduced to the concept of engineering and having close family role models seemed to be important for all three participants.

III. Question 3: Why do you think you chose engineering?

“It was definitely my strengths”

The CPE student talked about how she chose engineering due to her strengths in science and math fields. She had a high self-efficacy in those fields, which helped her to participate in more STEM courses in high school and

pushed her into engineering. Her high self-efficacy combined with family role models helped to establish her pathway to engineering success. She also cited that she wished to “help people” which fueled her desire to enter engineering.

“I love problem solving”

The participant from CHE talked about how she had an innate love of problem solving, but she also discussed how encouragement from her father influenced her decision to enter engineering. She expressed how she had a love of make up from a young age and how her father bought supplies for her to create her own make up in order to study how chemicals could combine and create a product. She also discussed how she loved problem solving and wanted to help people with her future work.

“the science portion just really interested me”

The theme of engineering being a strength due to math or science continued with the CEE participant. She discussed how she found the science portions of engineering to be interesting and how she believed that she could use her talents in that field to help people through civil engineering. This over-arching theme of helping people combined with a natural proclivity for STEM fields appeared in all three interviews.

IV. Question 4: Why do you think you chose your engineering major in particular?

“I had to take Computer Sciences classes in high school”

The participant from CPE cited that she chose her engineering major due to previous experience in programming classes and distaste for other engineering fields (i.e. biological and chemical). Her major choice was interesting as it was different from the engineering majors of her parents. This may indicate that while women benefit from engineering female role models, the role models may not need to be specifically from the student’s future engineering major. The participant also discussed that she enjoys the puzzle-like qualities of engineering and how engineering allows her to create an “actual product.”

“Chemical is extremely broad”

The participant from CHE went into detail about how the process of creating products intrigued her and helped her to decide her engineering major. She also expressed how personal preferences dissuaded her from other engineering majors, and she discussed how the breadth of Chemical Engineering attracted her to the major.

The CEE participant believed that she had answered this question in the previous section, but her previous response included that she wanted to help people with her engineering degree.

V. Question 5: Why do you think young girls lose interest in engineering?

“I feel like girls need that type of role model....someone to tell them that they are going to be good”

The participant in CPE mentioned that she believed that fewer women might enter engineering because the field is depicted as less “glamorous” by society than other more feminine fields, and then she continued, talking about the lack of female role models in engineering. She believes that females have fewer people telling them that they can succeed in fields such as engineering and that the lack of female community could be contributing to the deficit. Her responses were centered around the lack of female community in engineering and how that discourages women from participating.

“They [younger girls] don’t understand that they can too take the harder classes”

Conversely, the participant from CHE expressed more concern about societal pressures. She stressed that women are expected to go into what are typically considered to be more feminine fields such as secretaries, cooks, etc. The participant also believed that young girls are never informed how much variety exists within the engineering field. The participant expressed how these pressures could be affecting girl’s self-efficacy within engineering fields.

“it’s like we get steered away from it [STEM fields] rather than towards it like guys”

Societal pressures from a young age seemed to appear in the interview with the CEE participant as well. She wanted to emphasize that these pressures do not only come from adults, but that she had witness what she called “peer shut down” as well. The pressure for women to cease persisting in “masculine” fields emerges from a young age according to her. She discussed how her brother was almost a role model that allowed her to overcome those pressures.

VI. Question 6: What do you think is the hardest part of being a female engineer?

“the hardest problem is always being pointed out”

The student from CPE discussed the difficulties of frequently being singled out in class because of her gender. She cited how her male friends in class could not sit next to her without someone making a comment, even in her senior

year. She went on to describe the other issues that she had encountered, particularly with people being surprised when she would answer a question correctly in class. Interestingly, the all issues she discussed pertained to the perceptions of other people rather than issues with the difficulty of the work or lack of community.

“not seeing yourself throughout the day”

The theme of feeling different was continued in the responses from the CHE participant. She discussed her current position as an intern at a large company and how difficult it is “not seeing yourself throughout the day.” The participant went on to talk about how the only time she encounters other women at her internship is when she goes into the Human Resources department. This feeling of being different and not belonging seems to add extra pressure to the participant’s day, and she discussed how she had to battle the expectation that other people had for her to fail, daily.

“being told we, like, we can’t do it”

The last participant from CEE made it a point to discuss how her being a female affected the way that people viewed her as an engineering. She felt that it’s common for other people to doubt her abilities as an engineering student due to her gender, and she believed that her greatest obstacle would be the people around her. This makes it appear that the perceptions of other people can greatly affect how female engineers perceive themselves, even if some of these perception are not explicitly stated.

VII. Question 7: What parts of being a female engineer do you enjoy?

“I just enjoy what I’m doing”

“It’s not being a female engineer, it’s just being an engineer”

“I just really like where I’m going and the job opportunities for engineers”

The senior participants both expressed that there are some positives to being different from your peers. The participants from CEE did not discuss any positives about being different from her peers, but all three women discussed how they love engineering in terms of the math and science and the opportunities that engineering presents to them.

VIII. Question 8: Is there anything that I missed or that you want to add?

“Anyone can be an engineer if you just put your mind to it”

The CPE participant believed that I had covered most topics and had nothing more to add. The participant from CHE took this time to express how she believes that people can be an engineer and how she believes that more people need to be aware that engineering is a field that requires hard work. The participant expressed how people she encounters seem to have a misconception that engineering is reserved only for incredibly intellectual people, but she believes that the field is one that anyone can succeed in with determination.

“I feel like that's really important to get girls involved young”

The participant from CEE discussed mostly how she believes it is important for researchers to focus on recruitment plans for female engineers at a young age. She discussed how fostering a strong self-efficacy in younger women could help them overcome future obstacles and societal pressures.

DISCUSSION

I. Obstructions

Prior researchers have acknowledged and studied many of the obstructions discussed by the participants in this study. The female engineers in this study all discussed how the lack of community and lack of belonging could be both dissuading future female engineers and inconvenient to their daily lives. The participants also discussed how societal pressures affect younger girls in their major choices and how those pressures continue to affect women currently enrolled in engineering even through their senior year.

One common obstruction that these participants cited derived from a lack of community and feeling “different” in engineering. The participants in this study all expressed how the feeling of being different added pressure for them to succeed at higher degrees than their male counterparts. The women all discussed how being surrounded by only male peers would add pressure to their day. They also acknowledged how the lack of female community could be contributing to women’s lack of entry into the engineering field.

Some of the pressures described by these participants could be due to ongoing stereotypes about engineering being more “masculine.” The societal pressure for women to go into more classically feminine fields was a common theme expressed by the participants. The interviewees expressed that there is an overwhelming expectation for them to fail at engineering and overcoming

this barrier requires them to succeed at higher rates than their male peers.

II. Motivations

The participants who were seniors in engineering provided a more in depth perspective into the challenges that females in engineering face, but their distance from their major choice and pre-college decisions may have clouded some of the factors that influenced their decision to become engineers. The freshman engineer was able to provide more clear descriptions of what caused her to choose engineering. Overall, the factors that have been indicated as most influential in choice of major were: family history in engineering, strong role models, previous experience, and a desire to contribute to society and problem solve.

The idea of needing female role models and mentors for younger women is not new, but it was interesting that the CPE participant discussed how the type of female engineer did not matter as much as the encouragement she received from her role model or mentor. The mentor for the CHE participant, however, was a male, her father. This strong family influence from a young age seemed to embed the participants with higher self-efficacy. The senior participants expressed their confidence in their abilities in engineering and contributed part of this to early expectations to enroll and succeed within engineering.

The participants also all expressed a desire to help society as a whole and problem solve for this world. It has been theorized that women have a more nurturing nature that pushes them to take on roles to help society, thus it was interesting that this theme emerged within the interviews.

FUTURE STEPS

In the future, this project will be expanded to include more females from more engineering majors. Eventually, we will design a survey for a quantitative study where questions will be formed from the qualitative data collected from these interviews. The quantitative survey will then be distributed to a larger audience in order to increase the generalizability of the study.

CONCLUSION

The problems facing female engineers of today are not new, but the acknowledgement of these issues by researchers and female engineers creates a positive future outlook. Through these interviews, we have gained a better understanding of the hurdles that women still face in engineering fields. With a better understanding of these problems comes and understanding of the ways to fix the problem and increase enrollment of females in engineering. In the future, with

increased exposure to these problems, we can work to ensure that the ladies with the passion and aptitude for engineering are offered similar opportunities to be exposed to engineering and can establish better recruitment programs for women.

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