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Negotiating Gender in an Engineering Environment

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Jenefer Husman received a doctoral degree in Educational Psychology from the University of Texas at Austin, in 1998. She served as an Assistant Professor at the University of Alabama from 1998 to 2002, when she moved to Arizona State University. In 2008 she was promoted by ASU to Associate Professor. Dr. Husman serves as the Director of Education for the Quantum Energy and Sustainable Solar Technology Center - an NSF-funded Engineering Research Center. Dr. Husman is an assistant editor of the Journal of Engineering Education, has been a guest editor of Educational Psychology Review, served on editorial board for top educational research journals, and currently sits on the editorial board of Learning and Instruction. In 2006 she was awarded the U.S. National Science Foundation CAREER grant award and received the Presidential Early Career Award for Scientists and Engineers from the President of the United States. She has conducted and advised on educational research projects and grants in both the public and private sectors, and served as an external reviewer for doctoral dissertations outside the U.S. She publishes regularly in peer-reviewed journals and books. Dr. Husman was a founding member and first President of the Southwest Consortium for Innovative Psychology in Education and has held both elected and appointed offices in the American Psychological Association (APA) and the Motivation Special Interest Group of the European Association for Research on Learning and Instruction.

Negotiating Gender in and Engineering Environment

Abstract

Despite a recent emphasis on increasing female retention in engineering, data trends indicate that such efforts have had limited success. This study considered female retention in engineering by interviewing female students about why they entered and stayed in engineering. We conducted ethnographic interviews with six female engineering students about their experience in engineering. All students were attending a summer research program at an American southwestern university. Students ranged in age (19-35 years old) and academic level (forthcoming sophomore-senior). The interviews were semi-structured and were conducted by the first author - an engineering education researcher. Using a post-positivist constructivist perceptive, themes were extracted from the interview transcripts and grouped into thematic categories related to students' perceptions of women and engineering. Even though our sample was limited, commonalities emerged in the interviews for women's engineering experiences. Thematic categories were validated using established theoretical constructs. Five thematic categories emerged from the data: discovery of engineering, interest and persistence in engineering, discrimination within engineering, gender identity, and family-career balance. The thematic categories that emerged in this study represent our participants' shared experiences that influenced their choice to pursue and remain in engineering.

Introduction

Policy makers and media have put a spotlight on STEM's gender inequalities,[1] yet, engineering's public image suggests that the field has become more inclusive. The fact that Facebook hired Sheryl Sandberg, and support her efforts towards women leadership in technology is one example of the perceived change. Such high-profile female role-models should be celebrated. However, the expected motivational effects of high-profile female role-models are not yet translating to grass-roots female participation. In fact, the graduation rate of women from engineering programs is declining,[2] and women only make up 18% of the engineering workforce.[1]

Our study attempts to peel back engineering's public facade to gauge if current female students still perceive the engineering environment as hostile to women. Or do they perceive it as welcoming, suggesting that the efforts of Sandberg and others to promote women in technology symbolize a deeper culture shift not yet measurable in graduation rates?

The purpose of our research was to understand how the culture of engineering affects the interest and experience of women pursuing a career in the field. By conducting interviews with six female engineering students, we attempted to reveal commonalities about their experiences and perceptions of what it means to be a woman in engineering. By understanding the personal experiences of female engineering students, we hope to better understand how the culture affects future decisions about their careers.

Participants

We recruited six female students at a public university in the southwest United States during a summer Research Experience for Undergraduates (REU). The REU was a five-week total-emersion program in photovoltaic engineering. Students worked together in the research

lab and ate together daily during business hours. Throughout the program, students became comfortable being around each other. Out of 20 students in the program, 9 were female. This ratio represents an oversampling of women compared to a typical engineering classroom.[2] To protect the students' identities, participants in this paper will be identified with pseudonyms

At the time of the interviews, Andrea was 23 years old, White, and had just completed her first year in a semiconductor program at a private graduate school in the north east. Carla was 35 years old, White, and a junior in electrical engineering at a large southwestern university. Chantel was 20 years old, Black, and a junior in electronics engineering at a small, east coast college. She had started at a community college before enrolling in a four-year program. Chelsea was 28 years old, White, and a second year student at a small, rural community college in the southwest. Jessie was 19 years old, White, and a sophomore in mechanical engineering at a large southwestern university. Nicole was 22 years old, a White immigrant from Serbia, and had just completed her senior year in mechanical engineering and sustainability at a large southwestern university.

Method

Design

We carried out an ethnographic study using interviews and subsequent thematic analysis using the post-positivist constructivism perspective.[3] As such, the interviews and thematic analysis assumed that data were constructed by all participants in the study – including the perspectives and values inherent in our research team. Similar approaches have been used in gender studies focusing on sport[4] and engineering.[5]

Procedure

During REU orientation day, the first author, Nelson, introduced herself to the students and provided them with information about the study and our research goals. During the first week, Nelson participated in numerous activities and casually interacted with the students. Towards the end of the week she approached each student individually and asked them to participate in an interview discussing their perceptions of being female engineers.

All interviews were conducted face-to-face at the REU's host university in a conference room adjacent to the research laboratory. Nelson, who holds a Bachelor's and Master's degree in environmental engineering and a Ph.D. in curriculum and instruction: engineering education, conducted all interviews. She provided a unique background that aligned with the students, including working towards an engineering degree and participating in summer undergraduate research programs.

The interviews with the female engineering students were semi-structured. All of the participants were asked the same guiding questions, however, at the discretion of the Nelson, additional questions were asked when further elaboration was needed. The list of questions is provided in the Appendix. The questions were chosen and developed based on existing literature on women's paths in engineering[6] and motivation to succeed.[7] Interviews lasted approximately 45 minutes and were recorded using an audio device. Interviews were transcribed by Shapcott and an additional member of our research team using Nuance Dragon®.

Analysis

Nelson and Shapcott independently listened to the interviews, and read through the transcripts to identify the themes. They allowed for themes to emerge from the data in a 'bottom-up' inductive approach. When approaching the interviews inductively, themes were drawn from the data without a theoretical reference in mind, similar to grounded theory research methods.[8] Therefore, we sought to find descriptions related to our participants' perceptions of women in engineering without using existing general theories for women in engineering. These descriptions were then formed into general themes that captured the essence of our participants' perceptions of being a woman in engineering. Nelson interpreted the interviews with knowledge of the engineering culture, whereas Shapcott, who is pursuing a Ph.D. in educational psychology, framed it with a gendered motivational lens.

During the thematic analysis, Nelson and Shapcott made a list and associated description of themes as they read through each transcript. Larger thematic categories were created that grouped similar themes together. For example, if students talked about effort and help-seeking, they would be categorized together in the broader thematic category of interest and persistence in engineering. Nelson and Shapcott then re-read the transcripts multiple times. The purpose of the iterative process was to review any additional themes that emerged and to check that all thematic categories accurately represented the themes that composed them. When no additional themes were observed, the thematic categories were deemed to accurately represent the data. At that point, Nelson and Shapcott met to compare the thematic categories and their respective themes.

Despite Nelson and Shapcott's different backgrounds, agreement on the thematic categories was strong – the language used to describe each thematic category differed slightly, but the same thematic categories were seen by both researchers. The language for the thematic category descriptions was finalized. Thematic categories were validated by looking back through the literature and framing the categories within established theories. Thematic category names, descriptions, and an example are provided in Table 1. A summary of the emerging thematic categories follows.

Table 1

Thematic Category	Description	Example
Discovery of Engineering	Statements about how participants were exposed to engineering and became interested in it.	"He (her dad) introduced me to the engineering world and how it can challenge you and he would solve a lot of problems around the house and improve our lives"
Interest and Persistence in Engineering	Statements regarding why participants are interested in engineering and what steps are necessary for them to be successful.	"I'm at the point when I'm interested but I really want finish and move into the future."
Gender Discrimination	Statements associated with discrimination that the participants have experienced or the environment of engineering as being discriminant toward women.	"I feel like it might hinder me a little bit just because of like family and all that"
Gender Identity	Statements about stereotypes of what engineers should be and how the participants identified with that.	"I just think engineering overall is a man's role or game."
Family-Career Balance	Statements about how women and men balance families and careers in engineering.	"yes because it's traditional for the female to stay home with the children and that could set back their career several years"

Results and Discussion

A total of five higher-level thematic categories emerged from the participants' perceptions of engineering. These were; discovery of engineering, interest and persistence in engineering, discrimination within engineering, gender identity, and family-career balance. Each thematic category is described and situated using the comments made by the participants and existing theories.

Thematic Category 1: Discovery of Engineering

All students credited male role-models for helping them discover engineering. Chelsea, attributes her interest in engineering to her grandfather, an agricultural engineer, and cousin, a mechanical engineer. Interestingly, all students were exposed to engineering, usually by their role-models, at an early age and tinkered at engineering-type activities.

Jessie said "*I liked figuring out how things work and taking them apart and being able to physically move the pieces."* Jessie was not alone in remembering her childhood tinkering. Chantel "*I'm a hands-on learner and he [her uncle] was like it's a hands-on field so I started playing with stuff and took my PlayStation apart and put it back together."* Tinkering played a significant role in discovering engineering – when Andrea learned that tinkering was actually called engineering she recalled thinking "*oh, I can do that!"*

Our participants' reinforced research suggesting interest in engineering stems from consistent "tinkering," not from one pivotal moment. Interest development takes time, repeated

exposure, and high levels of engagement[7] and tinkering plays a role in understanding what engineering is.[9]

Thematic Category 2: Interest and Persistence in Engineering

We wanted to know if the students would recommend engineering to other women. The responses spoke more to the students feeling about engineering. What surprised us was the high level of intrinsic interest the participants had for engineering. They were passionate about the industry and what they hoped to achieve within it. Furthermore, they seemed aware that high levels of interest were necessary to persist through inevitable difficulties women face in engineering. Nicole said she would recommend a career in engineering for women only "*if they like it enough to put up with stuff and if they love the learning and just love engineering in general."*

Students' interest in engineering was also linked to a greater good. For example, Carla wanted to focus on solar engineering because "*I believe in solar and I believe in renewable energy. I believe the world needs it."* Andrea, said her interest in renewable engineering stemmed from furthering "*human well-being."*

Much has been written about women preferring "people" rather than "object" professions.[10] Our data supported Lippa's theory but it was unclear whether claiming that engineering solved "people" problems was participants' way to justify that their career choice as feminine, or an innate preference

Despite their deep-rooted interest in engineering, the students knew interest alone was not enough to pursue it as a career. In fact, they attributed their success not to their interest but to much more practical causes. Nicole said her success in engineering was due to "*a lot of hard work and long hours and studying."*

For most students, hard work was simply a choice they made. However, Chantel's story was remarkable. Chantel lives with her mother, her older sister and her sister's two children. She also works. She feels pressure to help her mother and her sister, who rely on Chantel for both time and money. Despite these distractions, Chantel does whatever it takes to succeed in school, including overcoming setbacks. She shared one of the setbacks she had with us "*I ended up getting a C- in calculus and you had to get a C to go on to the next class so technically I failed it because I had to retake it. I took it the last time and got an A, ever since I've gotten an A in every math course."* Chantel's story epitomizes the foundation of Dweck's self-theories research.[11] She believed she could improve her calculus ability with hard work and a strategic approach. Furthermore, Chantel framed setbacks and failures as learning opportunities. As a growth theorist (perceiving ability as malleable) Chantel was resilient and resourceful during an extremely challenging situation.

Thematic Category 3: Discrimination

We were also interested in participants' perceptions of discrimination and the implications for their careers in engineering. Interestingly, the participants struggled to identify specific examples of discrimination they had experienced as women in engineering. Overwhelmingly, their responses indicated that although they did not directly experience discrimination they felt they could be discriminated against when looking for a job. Jessie said *"I*

feel like society now is fair or almost fair to both men and women and I don't think that I will be discriminated against or have trouble doing the job or finding a job." However, she also stated, during the same line of questioning, that the downside for women going into engineering is "s*ome of the employers might be sexist and prefer men or think men are superior."* Steele (2002) showed that women are only mildly aware of discrimination in engineering, even though it is a facet of the culture. Our participants had similar awareness of gender-related challenges.

Older students, like Carla, were more aware of discrimination than the younger students, especially as it related to career success. It may be that younger students have not yet experienced discrimination. As Carla said *"I have to work twice as hard to be three times better than the best guy to be considered equal."* Reinforcing Steele (2002), our older participants felt that discrimination related to gender stereotyping had major implications for their success.

Thematic Category 4: Gender Identity

The students were acutely aware of stereotypes about engineers, but were optimistic that the stereotypes were changing. When asked to describe an engineer, Chelsea said *"when I was growing up I thought of them as old White guy sitting on the desk in the big office but now but now I see all sorts of different people."* Despite Chelsea's optimism, she acknowledged that her immediate surroundings still reinforced the old, White-guy stereotype.

Because engineering stereotypes are incongruent with students' gender identity, they struggled with how to present themselves as engineers. This certainty is not unique to engineering and women deal with incongruence in different ways.[13] The REU made clothing choices easy for the students – they were all required to wear jeans, a t-shirt and tennis shoes. However, when applying for jobs, the students worried about their gender incongruence and knew it needed to be carefully navigated. Chantel thought identifying with the dominant gender would be pragmatic "*I think I should be presented as more male like with business clothes."* As a lesbian, Andrea was perhaps more comfortable with bucking gender roles and preferred an androgynous approach to engineering "*so I'm less able to be boxed in."* Andrea's comment was not unlike what was described by Secules, Gupta, and Elby (2015), in that Andrea did not want to be marginalized based on gender.

Thematic Category 5: Family-Career Balance

When exploring participants' perceptions of a future family-career balance, our questions elicited responses indicating that acknowledged obvious tension between family and work commitments. This tension appeared to be driven by the bigger social implications of having children while in the workforce. These perceptions suggest that family still represents a resource for men and an obstacle for women.[15] Jessie stated: "*it's traditional for the female to stay home with the children and that could set back their [female engineers] career several years."*

Considering the tension and social implications, participants described different strategies to achieve a family-career balance. For example, Nicole (age 22) commented, "*I've actually thought maybe I'll never have kids because it seems too much of a hassle with your career."* In line with Watts (2009), some participants strategically choose to focus on careers, not family, and adopt male-like work patterns. Others, like Jessie and Chantel (aged 19 and 20), believed that achieving a family-career balance will be easy and are perhaps unrealistically optimistic about finding it. Jessie stated, "*I feel like in taking care of the child women and men are almost*

equal." Again, a distinction appeared between the older and younger students. The older students were more realistic about difficulties while the younger women were more idealistic about a family-career balance.

General Discussion

Our study's goal was to understand how the culture of engineering affects the experiences of women within it. This paper presents a general overview of thematic categories that emerged from interviews with six female engineering students. By framing students' perspectives in established theories, we validated the generated thematic categories.

Although we acknowledge the limitations of this study; capturing a snapshot of stories from a small sample of female engineering students, it offers insight into how the culture of engineering is perceived today by women within it. The students did not perceive engineering as an overtly hostile environment – in fact, they acknowledged the challenges but seemed determined to overcome them. Sheryl Sandberg's presence at Facebook will only help.

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Appendix

Interview Questions

1. What contributed to your becoming an engineer?
2. What contributed to you wanting to participate in this program?
3. Who are your engineering role-models?
4. How did you connect with engineering?
5. Did you have exposure to engineering at a younger age?
6. What type of engineering are you interested in, and why?
7. Did you find support to pursue engineering? This program?
8. Tell me how you would describe the person you are now? What contributed to this the most and why?
9. What has been the most helpful during this program? What has been the most helpful for your pursuit of an engineering degree?
10. Where do you see yourself in a year, two years, five years, for your career?
11. What do you feel are the best ways to encourage more girls to pursue engineering
12. After going through the experience of choosing engineering, what advice do you have for other women in your situation?
13. Is there anything else you think I should know about women/females pursuing a degree in engineering
14. What are the good things and bad things about being an engineer?
15. What challenges do you feel lay ahead as you pursue your career? How will you overcome them?
16. What challenges have you or do you currently experience because of your degree choice?
17. As you look back, are there any events that stand out that affected your choice to pursue engineering? This program?
18. Do you think being a woman will help your hinder your career as an engineer? Why?
19. Are male and female engineers equally rewarded for the same work?"
20. Do you think there are preconceived expectations of your performance because you are a woman? If yes, can you think of an example?
21. Do you feel you have to prove yourself as a woman?
22. Do you think female students are taken less seriously?
23. Do you feel like you're going to be equally compensated?
24. As a female, do you feel that it hurts you're chances of being an engineering/having an engineering future?
25. Do you plan on going to graduate school, working in industry?
26. Where do you think women are more likely to be successful when pursuing engineering (academia, industry, etc.)
27. Do you consider career/family life balance to be something women have to consider more than men?
28. Do you feel that career/family life balance is a hindrance to women's success in engineering?
29. Do you consciously feel that you have to fulfill certain gender roles – or do you feel like you can deviate from that?
30. Have you ever experienced any discrimination?
31. Would you encourage girls to go into engineering, how you would you do that, and why?
32. What are the down sides for girls going into engineering?
33. What do you attribute your success as an engineering student to?

34. Describe a stereotypical engineer
35. Do you feel smart enough to be an engineer? Do you feel that the women who left engineering did so because they weren't smart enough to be successful
36. Do you feel that men are smarter than women? How do you account for the discrepancies in the number of males vs. females that persist?
37. Do you feel that you can be a caregiver, creative, or other facets of what you feel you are as a woman?
38. Do you think that working in industry will be similar to your experiences in academics/undergraduate education?