Professors' Perceptions of How Men and Women Students Experience Engineering Education Differently…Or Not

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INTRODUCTION

For decades now there have been significant efforts to increase the numbers of women in engineering, and yet women remain drastically underrepresented in engineering in Europe and the United States [1]. One defining characteristic of prior research and outreach efforts aimed at addressing underrepresentation is that they examine only students. Advancing the research landscape now requires new research approaches that focus on faculty, rather than students, in other words, "studying up". Faculty pedagogy and interactions have been shown to play a significant role in students' decisions to leave STEM majors, and female students in particular report experiencing negative classroom interactions [2]. However, no research has been done to characterize what and how a large group of engineering faculty members thinks about gender in engineering education. There is a critical need to identify what and how faculty members think about gender so that effective interventions can be designed to target those ways of thinking, and, ultimately, increase gender equity in engineering education. This paper begins to addresses that gap in research by presenting findings on how a group of 35 engineering professors from three different institutions in the United States discuss differences in men's and women's experiences in engineering programs. The central questions addressed in this analysis are: 1) Do engineering professors think men and women experience engineering education differently? And 2) What do engineering professors say are the most salient differences in the experiences men and women students have in their engineering programs?

1. BACKGROUND

1.1 Research on Students' Experiences

In a recent overview of literature on the causes of women's underrepresentation in engineering, Lehr and colleagues divided explanations and research into three broad categories: *the social structure of society*; *the social structure of STEM education and profession*; and *the content and application of STEM knowledge* [3]. Although discourses related to the social structure of society also emerged in my interviews, the analysis at hand focuses on questions related to the social structure of STEM education, specifically the ways in which men and women might have different experiences of and in engineering education.

Prior research on students' experiences demonstrates that classroom experiences and interactions with other students and faculty disproportionately cause negative experiences for female and other minority students and lead to attrition from engineering programs [4]. One of the most in-depth studies on the topic concluded that, "women and other students who do not fit the prevailing norm are disproportionately affected by problems like poor teaching, hostile peers, or unapproachable faculty. Perhaps the most important place to start is the classroom experience" [5]. Tonso's ethnography also identified numerous ways in which engineering education is gendered [6], as have Seymour and Hewitt and Du and Kolmos' [7]. Further emphasizing the need to focus on faculty, Mills and colleagues have identified numerous facets of engineering curriculum and pedagogy that can be considered gendered, including: assumptions about students' experiences, values, and backgrounds; aims and objectives of the course; forms of assessment; course content; teaching and learning methods; teaching practices; and the learning environment [8]. Specific issues that have been identified as problematic for female engineering students include: spotlighting [9], being the token female team member [10], masculine communication expectations [11], the topics of example problems [12], and unsupportive faculty [13]. Collectively, these studies demonstrate that the structure of STEM education plays a pivotal role in the experiences and attrition of female engineering students.

1.2 Research on Faculty Perceptions

To what extent are engineering faculty members aware of these issues and biases? That question has not yet been explored in interviews with a large group of engineering professors. Almost all researchers who have studied gender in engineering education have taken students as their subject population. Hence, there is a need start "studying up" [14] by examining what and how faculty members think about gender in engineering education [15]. The amount of research on student experiences of engineering education is vast in comparison to our knowledge of what faculty know and think about those experiences.

The small number of researchers who have made faculty the subjects of inquiry have not directly examined what and how they think about gender in engineering education or women's underrepresentation. Covington and Froyd discuss initiatives to change faculty attitudes vis-à-vis gender inequities and present some data on the experiences of participants in those initiatives, but did not conduct a systematic study to first determine what those attitudes were [16]. Rosser and Kelly and Margolis and Fisher likewise describe results of initiatives at single universities to change the content and pedagogy of science and computer science classrooms, but again data are from participants in those programs [17]. Rosser and Kelly gave science faculty quantitative surveys with questions, such as "I think that women's speech patterns and other verbal and nonverbal methods of communication cause their answers and theories of science to be valued less than men's" and "I think that the traditional presentation of certain subject matter, for example, word problems, physiology, use of surnames, in the field may be sexist" [18]. They found that agreement with these statements increased after the intervention. Other work of relevance is that by an interdisciplinary group of scholars in Australia. In one paper, Mills, Ayre and Gill compared faculty members' perceptions of ways and extent to which "gender inclusive" engineering curricula had been effective over a ten-year period in which it was introduced and found that in all except one category, faculty

members perceived their practices are more inclusive than the students did [19]. In other work, Mills, Franzway, Gill and Sharp surveyed and interviewed practicing engineers in Australia and identified a pervasive "epistemologies of ignorance" among the engineers when it came to the question of why women were underrepresented in engineering [20]. None of these studies however has produced a large amount of qualitative data specifically intended to better understand what and how engineering professor think about gender in engineering education or women's underrepresentation in engineering.

2. METHODS

This study was designed in order to address that gap in research. Data collection is on-going. The preliminary analysis presented herein is based on semi-structured interviews with 35 engineering professors from three different institutions in different parts of the United States. Recruitment efforts are discussed in detail elsewhere [21]. *Table 1* summarizes the groups who participated in the study. Nine different nationalities were represented, and five racial or ethnic groups.

Table 1. Participant Overview

Group	N Participated	N Invited
Women	16	59
Men	19	87
Assistant professor	10	40
Associate professor	11	43
Full professor	14	63
Electrical/computer	7	22
Civil/environmental/construction	6	22
Industrial/operations/manufacturing	5	15
Chemical/biological	4	14
Aerospace	3	11
Nuclear	3	8
Materials	3	12
Mechanical	2	27
Biomedical	1	11
Other*	1	4

**Small, unique discipline, obscured to protect participant's identity*

Recruitment was done through a combination of maximum variation sampling and purposeful random sampling [22]. The goal was to recruit interviewees who were randomly selected in order to avoid a participant pool who primarily had involvement with women in engineering initiatives. Public, departmental websites were used to randomly generate names, and within the parameters or random sampling, purposeful steps were taken to recruit a full range of engineering disciplines, career levels, and an approximately even number of men and women. The interviews covered a wide range of topics that have been identified in prior scholarship as contributing to either the gendering of engineering and/or women's underrepresentation in engineering. The overarching aim of the interviews was to better understand what and how engineering faculty members think about gender in engineering. The responses to one particular question are discussed in this analysis. I asked interviewees to think about what it might be like to be a female engineering

student at their institutions, and what it might be like to be a male student, and to tell me what they thought the most salient differences in their experiences as engineering students might be.

3. FINDINGS AND DISCUSSION

On the whole, those interviewees who did identify ways in which women might have different experiences than men demonstrated awareness of a wide range of potential experiences, all of which have been identified as problems in prior research. However, individually each interviewee only mentioned one or two of those issues, suggesting that there is room to raise awareness of these issues more broadly among faculty members. In addition to the issues identified in *Table 2*, many interviewees also discussed how men do not have to think about gender at all, how they do not have anything to prove, and that this likely leads to greater confidence and being more "fearless." Several also discussed differences in the actions of female students, namely that they were less likely to "speak up" in class, more likely to visit office hours, and more likely to participate in professional activities. For the most part however, the responses were quite vague. They described a general sense of being "uncomfortable" and very often compared it to being any other kind of minority in a group. Very few identified specific actions from faculty and other students that contribute to gender biases.

Table 2. Differences identified

Response	# Men	# Women
Feeling uncomfortable and not belonging	9	3
Harder to find friends and social networks	5	1
Lack of role models	3	2
Treated differently	4	1
Subject to biases and stereotypes	4	1
Mostly male professors	2	2
Safety and sexualized environments	3	0
Relationship to content/pedagogy	1	1

Only two interviewees refereed to the content and pedagogical practices of engineering education when answering this question. In other parts of the interviews, I do ask questions specifically about content and pedagogy however, and findings related to those topics will be discussed elsewhere. The two quotations below reveal awareness of how women might come to engineering education with a different relationship to common content than men:

> I do think many of the examples and ways we teach are learn-by-doing, is very mechanical based, lots of nuts and bolts and car parts and airplanes, and things that might be classified as kind of male-interested systems and products and things like that. I think about some of my daughter's interest in things like that and those kinds of things that she's interested in is just not really part of my repertoire of experience and examples and things like that. So, for whatever reason I love airplanes and I talk all the time about airplanes, and I'm sure that many students and maybe a higher ratio of female students really don't care about those things I find extremely interesting. [male, full professor]

> I think that in general the hands on kind of machining…the manufacturing orientation of like all the freshman have to go through these machining classes…I think that in general it's easier for guys to do that stuff and that they're more apt to be more familiar with it than a woman. You know, they throw them into –"Okay, use this lathe"- and of course there's an empowerment to that like "Okay wow I don't think I can do this and then I can do it", so that's the learn by doing that's really great, it gives people that experience, but I think that the anxiety of that is higher for women than it is for guys…I think we forget how much that trips people up, that initial stuff. [female, full professor]

Three interviewees, all men, discussed some aspect of safety or sexualized environments women encounter by virtue of working among mostly male students and professors. These are issues almost never discussed in engineering, despite the fact that there are reasons they may be even more salient in engineering than other majors, such as the large majority of men, and significant amounts of team and project work, often requiring late night and out of classroom work. It is also possible that these issues are some of what other interviewees were trying to convey obliquely when they recognized that women might be "uncomfortable" in engineering education.

Far from all interviewees gave even one potential difference. As summarized in *Table 3*, it was also common for interviewees to say that there were no differences, that they did not know what the differences were, or to discuss the perception that women had advantages.

Table 3. Differences not identified

Response	# Men	# Women
No difference	5	5
Do not know	5	3
Cannot generalize	3	1
Women have advantages	2	0

It is true that not all women experience engineering education the same way and that not all men experience it the same way. In that sense, it is positive that several interviewees recognized the problem of generalizing across the groups. It is also true that some women might experience education in the same way as some men. However, the large number of interviewees who said that there was no difference between the experiences of men and women is troubling because prior research shows that very often there are differences that negatively affect women, and responses suggest that faculty were unaware of those differences. Perhaps even more striking are ones that asserted there was no difference but then went on to say that women might be treated differently, but because it was not discrimination from official channels, it was trivialized:

> I would say that here…there's not much difference to their experience. I think there might be subtle things here and there like females might get treated differently to the males by certain members of the faculty. Or there may be some experiences that females have outside of the classroom. You know I've

> heard, very third hand, of female students being, not receiving verbal abuse, but being talked down to by their fellow students, the male students. So those things are kind of due to different individuals. I think…to the best of the university's ability at least – the overall culture seems as even as it can be. Does that make sense? I mean the culture that's coming down from the top at least. Even if, at the bottom, obviously how individuals act towards each other is up to them…I mean I think, females definitely get a different experience, but it's because of personal interactions, I think. [male, associate professor]

There was also a high number of interviewees who said they simply did not know what the differences might be. For several of those, it went beyond saying they did not know to arguing that because they were in the majority they could not understand the experiences of women in engineering:

> So that one is hard for me to answer. One thing I've learned from a number of years being involved in discussions on diversity issues is that, it's relatively easy to say, "Okay, if I'm in a significantly underrepresented group, feelings of isolation are easy to experience." The other thing I've learned is that I can't possibly really – in a deep way, at least – understand that perspective, not having shared it. I mean being a white male it's fairly rare that I feel that I'm an underrepresented part of a group. I've been in situations where I'm the only white male – yeah, that does happen, but it's relatively rare, and honestly, you tend to laugh about it when it happens. If you're one of 5 or 6 female students in a class of 100, or if you're the only black student in the group, or something, I can recognize that as an issue, but I'm reluctant to pontificate about what that person's experience is like. I just don't have the perspective. [male, associate professor]

Another male associate professor similarly stated, “I don't know. It's hard for me to put myself in a woman's place.” On the one hand, these responses show insight and awareness that members of majority groups may not be able to truly understand what it feels like to be a member of a minority group. On the other hand, it is problematic if that is being used as an excuse to justify lack of awareness about issues of which much has been written. One can have knowledge about problems without having personally experienced them.

It is also worth nothing that several interviewees answered this question by referring a perception that women in engineering have advantages over men. One was discussing this perception among male students, but not agreeing with it himself, but the other said that because there is a desire to hire women and minority faculty members, they get “helpful” and “positive” attention.

4. CONCLUSIONS AND FUTURE WORK

Some interviewees were able to identify some ways in which women might experience engineering education differently than men, but they did not identify a full range of issues, nor were they able to talk about issues in specific detail, for the most part. They described a general sense of being “uncomfortable” and very often compared it to being any other kind of minority in a group. Very few identified

specific actions from faculty and other students that contribute to gender biases, despite the fact that numerous, specific problems have been identified in prior research. There were also a high number of interviewees who said they simply did not know what the differences might be, or, more troubling, that there were no differences, thus echoing findings by Mills et al. on "epistemologies of ignorance" [23]. It should also be noted that what I can claim to report here is what professors *told* me they think, and it is possible that their responses do not reflect what they really think. This project is on-going, and I move next to the tasks of completing my dataset, elaborating findings presented here, connecting this data to the rest of what was said in interviews, connecting that to larger discourses and elaborate problems therein, and creating faculty interventions. I welcome ideas on the latter.

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