Understanding the Male Student Perception of Culture Climate for Women in Engineering Education

Ms. Alexis Nicole Barney, Iowa State University

I am an undergraduate student at Iowa State University, studying Math Secondary Education. I began my studies as an aerospace engineering student and quickly noticed a chilly culture climate for women studying engineering. I decided to conduct research on the topic to see how the dominant group (white-male students) views these issues and what are they doing to solve them. Furthermore, I explored what could be done to improve the culture climate for minoritized groups, inevitably raising retention rates in engineering programs!

Dr. Benjamin Ahn, The Ohio State University

Dr. Benjamin Ahn is an Associate Professor at The Ohio State University in the Department of Engineering Education.

Mr. Matthew Nelson, Iowa State University

My background and interests are in RF, embedded systems, and engineering education. I have a B.S. in Electrical Engineering and a M.S. in Computer Engineering both from Iowa State University. I am now working towards my PhD in Engineering Education in th

Understanding the Male Student Perspective of Gender Inequity in Engineering Education

Abstract

It is well known that female students often experience a "chilly" cultural climate in engineering, affecting many student outcomes, including persistence in engineering programs, but the current literature lacks a comparison of women's experiences across different engineering disciplines. Perspectives of male students on gender equity and perception of cultural climate across different disciplines are also missing. We studied three engineering disciplines—aerospace, civil, and chemical—with varying proportions of female students to investigate the following research questions: 1) What is the current state of the cultural climate for women studying engineering in their respective disciplines at the studied university? How do increased proportions of female students impact the cultural climate in each engineering discipline?; 2) What is the male students' perception of the cultural climate for women in their engineering discipline?; 3) Is there a disconnect between the cultural climate female students experience and the perception male students hold of the cultural climate?; 4) What can be done to create meaningful changes to the cultural climate for women at the university level? To answer these questions, we designed a survey and semi-structured interview for female and male engineering students across the three chosen engineering disciplines. Our study is consistent with the literature, finding that women are still experiencing a chilly cultural climate due to peer tensions, gender discrimination, and feelings of isolation. Our data exhibited trends indicating that women in engineering fields with greater proportions of female students experience fewer instances of gender discrimination and feelings of isolation than those in fields with lower proportions of female students. However, based on the demographics of our study, these results are inconclusive. Our findings also show a large disconnect between what women report experiencing and how the male students perceive the cultural climate. We argue that understanding the male-student perspective of the cultural climate for women is critical for developing meaningful interventions for gender-related issues in engineering education. Lastly, we discuss intervention suggestions made by participants to spread awareness and create meaningful changes to gender-related issues in engineering education across engineering disciplines. We compare these new perspectives to the suggestions for meaningful changes already established in the literature.

1. Introduction

It is established in the literature that women often experience a "chilly" climate in engineering education. Walton et al. [1] summarize this chilly climate as "explicit and implicit messages that convey to women that their gender could be a liability in STEM settings. Indeed, women may encounter ambient cues that represent STEM fields as masculine, stereotypes that allege that women lack ability and men in STEM settings who treat women in subtly sexist ways. In this climate, even highly skilled and motivated women may wonder if they will be fully included, valued, and respected in STEM." Strategies for improving the cultural climate for women studying

engineering have been implemented and are well documented in the literature, which we discuss in our literature review.

Understanding the different ideologies male students hold around issues of gender equity is important for the state of the cultural climate in engineering education. In an article about poverty ideologies in education, Gorski [2] says, "Our understanding of the problem drives the solutions we are capable of imagining. Our choices of solutions determine the extent to which the strategies and initiatives we adopt threaten the existence of inequity or threaten the possibility of equity." The same applies to issues of gender equity; our understanding of the current state of gender equity in engineering education directly impacts the solutions engineered to create more equitable and inclusive environments for students.

Our research questions aim to better understand how male students in engineering perceive gender equity, which is the first step in creating a shift in the engineering cultural climate. If we understand how male students perceive gender equity, educational efforts can be made to reframe harmful ideologies on gender equity for women and other minority groups. If dominant groups can understand the experiences of marginalized groups, differentiate between equality and equity, and spread awareness of social issues, the future of engineering will be much more inclusive.

2. Literature Review

2.1. Culture Climate for Women in Engineering

Based on the extensive available literature, we know that gender discrimination is a factor of attrition for female students in engineering education. Studies show that 20-50% of women experience gender biases and sexual harassment— defined as a type of sex/gender discrimination that encompasses gender harassment, unwanted sexual attention, and sexual coercion— in their studies [3]. A full list of definitions for our study is listed in Appendix C. While sexual harassment occurs less often in environments where it is actively discouraged, women still experience more subtle and often unnoticed forms of gender discrimination. Studies show that this discrimination can occur through gender biases, different forms of sexism, and microaggressions, which are common behaviors that promote hostile, derogatory, or negative conceptions about women [3].

In a literature review, Malicky found that women experience a chilly climate in engineering due to two primary factors: "discrimination and the competitive/weed-out culture" [4]. Our study focuses on discrimination by looking at different forms of sexism, gender biases, and microaggressions that contribute to the hostile environment described by women in engineering programs. Forms of sexism contributing to this chilly climate include overt and covert sexism [5]. Overt sexism is experienced less frequently by female students than covert sexism in engineering education and is described as unequal and harmful treatment towards women that is apparent and observable [6]. Covert sexism is sexism that is either hidden or unnoticed because it is built into cultural and societal norms [7]. A definition and example of covert sexism can be found in Appendix C. Our research addresses how the proportions of female students affect the cultural climate, which is a gap in the current literature. In short, do women in fields with lower proportions

of female students experience a chillier cultural climate than those in fields with greater proportions of female students?

2.2.Male Perspective on Gender-Related Issues in Engineering Education

While there is some existing research on male faculty perceptions of gender inequities and their impact on the chilly cultural climate, there is a gap in the literature regarding male student perspectives and their impact. Warren and Bordoli suggest that male allyship has the potential to help shift the chilly climate while also offering instrumental, emotional support to reinforce current institutional efforts to promote equity. In an article focusing on male and female faculty's perspectives on allyship for women in male-dominated fields, Warren and Bordoli lay out a framework for male ally behaviors. Allies actively stand up for marginalized individuals, make invisible transgressions more visible, disarm microaggressions, educate perpetrators of gender inequities, amplify marginalized voices, and provide instrumental and emotional support for women [8]. For the sake of this study, a male ally is defined as a man who can identify gender inequities and respond appropriately through the means listed above.

In a study focusing on male faculty's perspectives on gender equity in STEM education, Sattari and Sandefur found that men often hold a gender-blind or gender-sensitive ideology to gender-related and STEM-related issues. Gender-blind views hold that gender neutrality is the key to gender equality, while gender-sensitive views recognize that women face additional challenges due to the "subtle gender dynamics" created by the disproportionately low representation of women in engineering. The authors of this study argue that recognizing the role of gender functions as a source of inequality is the first step for men in working towards positive change on this social issue. Sattari and Sandefur write, "The differences between the types of attitudes and professional performances that gender-sensitive versus gender-blind perspectives can promote among men highlights the importance of paying attention to men's views when designing initiatives for creating gender equality in STEM. Men's perceptions of gender issues have consequences for women's conditions in STEM in terms of interpersonal relations with male colleagues, opportunities for advancement, quality of mentoring, and the overall institutional culture" [9]. With very few studies exploring the male-student perspective of gender-related issues in engineering education, our research aims to address a gap in the literature and understand the ideologies male students hold that either promote or threaten gender equity in engineering education.

2.3.Established Strategies for Improving the Culture Climate for Women in Engineering

Friedrich, Sellers, and Burstyn [10] note that the following strategies have been well established in the literature to improve the cultural climate for women studying engineering: increase awareness of the social issue, inclusive teaching strategies, and intervention programs to increase equity for minoritized students. Faculty and instructional staff can raise awareness by giving students the opportunity to reflect on their experiences with diversity and its value. Students often only have these conversations on diversity with people with the same beliefs, so ideologies are rarely challenged. Inclusive teaching strategies can promote gender equity through thoughtful selection of course materials, cross-cultural communication, using teaching methods that include students of diverse learning styles, encouraging student confidence, interaction, and class participation, and using assessment and evaluation methods that provide meaningful data on each student's experiences and knowledge gained within the class. Lastly, intervention programs are

specialized programs to help students from underrepresented groups succeed in STEM. These resources improve students' success and retention in engineering programs and promote equity in engineering education [10]. Qualitative results from our study show that when these strategies are implemented in a classroom or on campus, students feel safe and included in their academic environment. However, female students still report a chilly social climate in engineering education. These results are further discussed in the results section. By looking at unaddressed perspectives, our research explores what new insights both male and female students bring to improving the cultural climate of engineering.

3. Method of Study

Our study surveys the cultural climate of three engineering disciplines at a large midwestern university with varying proportions of female students to see if women in fields with lower representation experience a chillier cultural climate than those in disciplines with higher representation. Participants were recruited from the university's aerospace, civil, and chemical engineering programs. Programs were selected based on the low, medium, and high percentages of women enrolled in each program respectively. At this midwestern university, women make up 13% aerospace engineering students, 20% of civil engineering students, and 36% of chemical engineering students. These percentages were collected from enrollment information at the studied university.

All students enrolled in each discipline were sent a survey via email for voluntary completion. The survey collected the following demographic information: gender, age, major of study, year in school, GPA, and international status. This paper focuses on the intersection between gender and the major of study. The gender and major of the study survey participants are described in Table 1. The survey consisted of 37 questions and had 106 respondents. Participants were not obligated to answer every survey question, so the number of responses vary for each question. Due to this, the percentages reported throughout the results section are calculated based on the total number of participants who responded to each specific question, rather than the total number of participants overall. For more information on the survey participant demographics, see Appendix A.

Table 1: Gender and engineering discipline of survey participants.

Gender	Aerospace Engr.	Civil Engr.	Chemical Engr.
Male	41	11	7
Female	14	14	19
Total	55	25	26

Our research team wrote survey questions to measure the frequency and severity of overt and covert sexism, gender biases, microaggressions, and other factors of a chilly cultural climate toward women, as found in our literature review. Examples and key definitions were provided to participants in each survey question (see Figure 1 and Figure 2). The survey questions were vetted through a pilot study consisting of five male and five female aerospace students. Faculty at the studied university reviewed the survey questions and gave the research team feedback. The survey

questions were edited based on the pilot study participants' and faculty's feedback and responses. A sample of the survey questions can be found in Appendix B.

The survey responses from women act as a benchmark for the current state of the cultural climate in engineering at the university. Similar questions were given to male participants for comparison with female participants' responses. The wording for questions was changed slightly to meet the perspective of the appropriate audience.

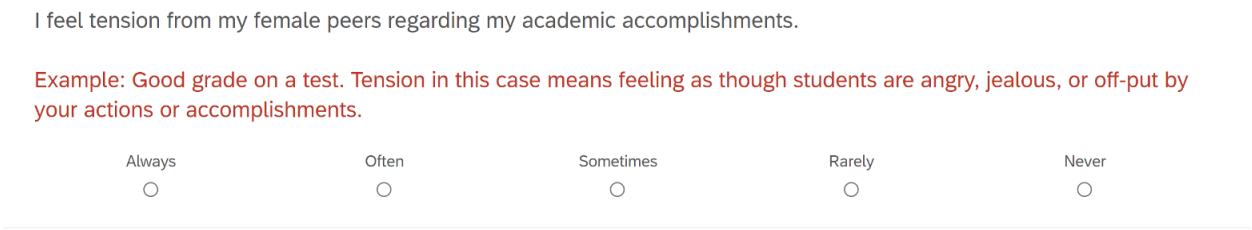

Figure 1: Example of a survey question and example provided to participants

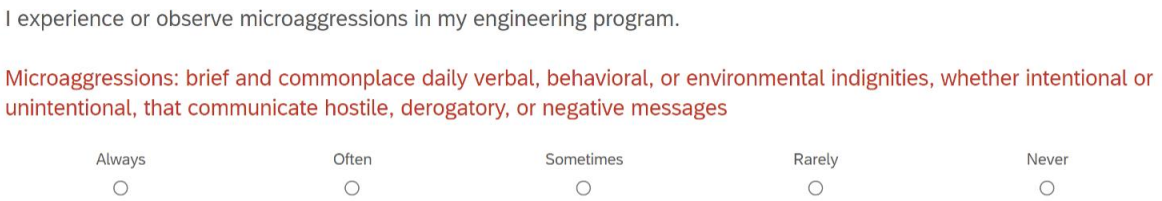

Figure 2: Example of a survey question and definition provided to participants.

At the end of the survey, participants were given an opportunity to participate in an interview with the PI to further discuss their experiences with gender equity in engineering education. The interviews were conducted via Webex meeting software and were one hour long. In the interviews, students were asked about their experiences and perceptions of gender equity, inclusion in the classroom, educational efforts they have experienced to raise awareness on the social issue, and suggestions for meaningful changes to the cultural climate for women in engineering education. Participants were provided with key definitions and examples while answering the interview questions. A sample of the interview questions can be found in Appendix B.

Demographics collected from the interview participants include gender, major of study, and year in school. Race and ethnicity were not directly collected in this study. The race and ethnicity of our participants are noted throughout this paper only when participants shared them during their interviews. The key demographics for our interview participants are described in Table 2. See Appendix A for more information on the interview participant demographics.

Table 2: Gender and engineering discipline of interview participants.

Gender	Aerospace Engr.	Civil Engr.	Chemical Engr.
Male	5	0	1
Female	5	2	1
Total	10	2	2

4. Results

4.1. Findings from RQ1: What is the current state of the cultural climate for women studying engineering at the university level?

There were three common themes from the survey data indicating the current state of the cultural climate: (1) tension felt by peers regarding academic and career accomplishments, (2) instances of overt and covert sexism, microaggressions, and gender biases, and (3) feelings of isolation and lack of ability by women.

4.1.1. Tensions between Genders

Figure 3 and Figure 4 show that 60% of our female survey participants report feeling tension from their male peers regarding their academic accomplishments sometimes–always, and 79% feel tension from their male peers regarding their career accomplishments sometimes–always. One of our female interview participants commented,

> "They've [male peers] either expressed it to me or I've heard people say I only got this job because I am a woman, and they [companies] need to fill a quota or the company needs to do this for diversity and inclusion. Unfortunately, being an Asian woman, I have an added level of minority, so I definitely heard a lot that I just got this to fill a quota. So that's obviously discouraging to hear. But, again, it's something that's very real. I know a lot of people have dealt with it." (Female, Aerospace, Senior, Asian)

I experience tension from my male peers regarding my academic accomplishments.

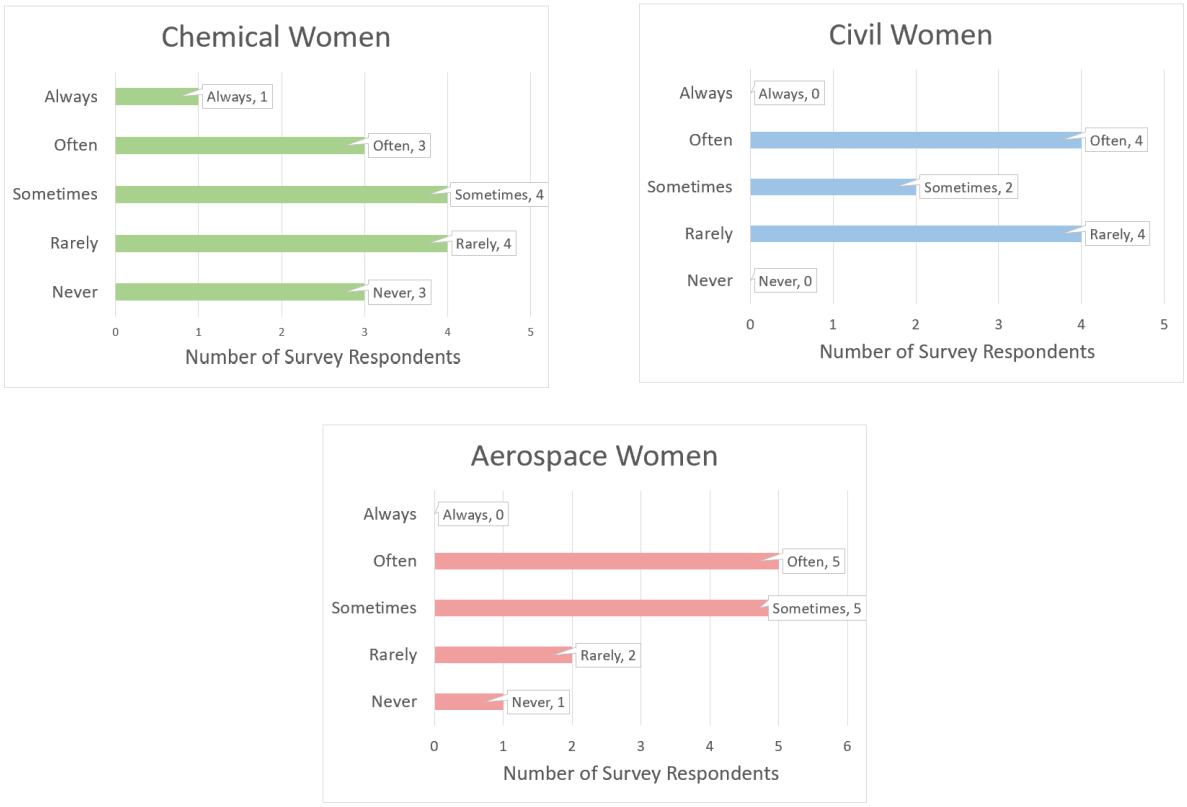

Figure 3: Female students rate the frequency of feeling tensions from their male peers regarding their academic accomplishments.

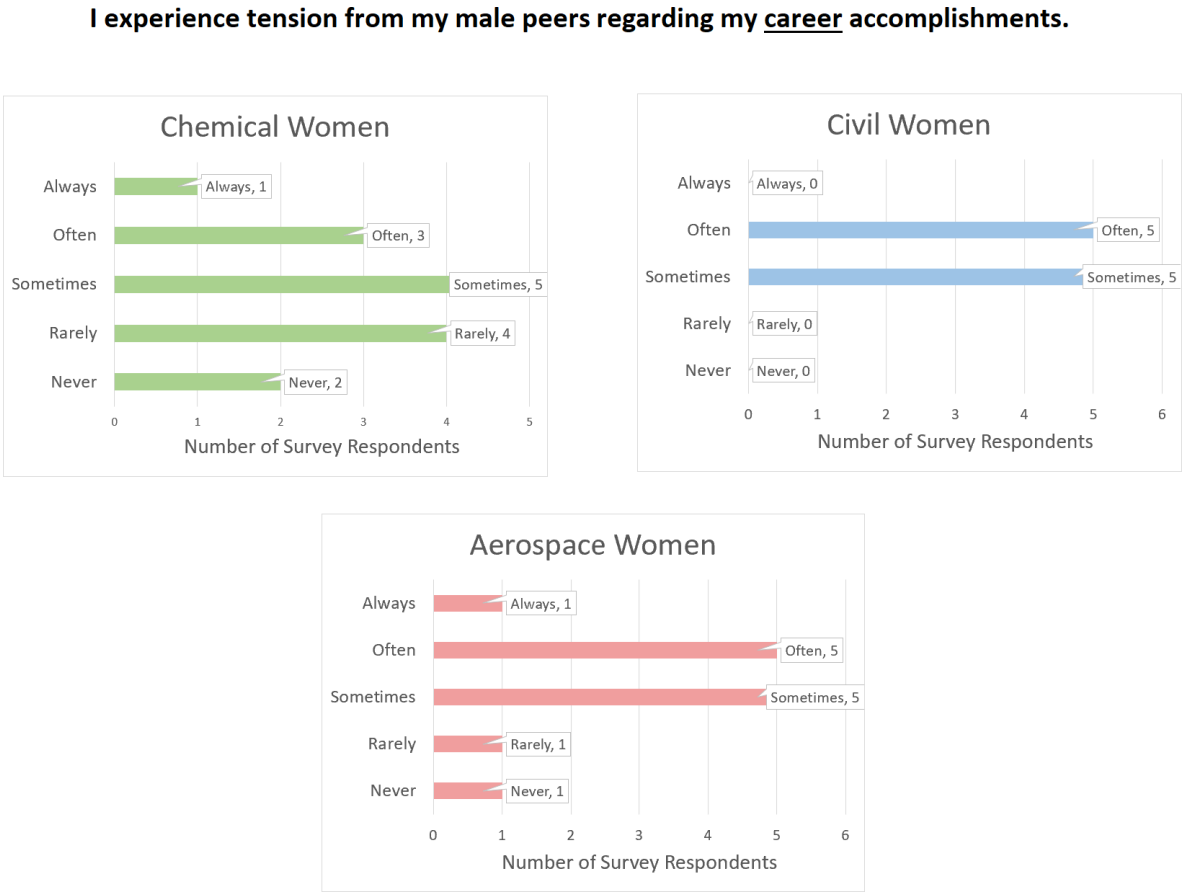

Figure 4: Female students rate the frequency of feeling tensions from their male peers regarding their career accomplishments.

4.1.2. Types of Gender Discrimination

Figure 5 and Figure 6 show that 36% of our female survey participants report experiencing instances of overt sexism sometimes-often in frequency, and 64% report experiencing instances of covert sexism sometimes-often in frequency. Figure 7 shows that 67% of female participants report experiencing microaggressions while working towards their degree. One survey participant commented,

> "I do not feel pressure in my day-to-day life. The most common thing I see or hear is mostly centered around comments that are meant to be in jest but are actually degrading and have sexist undertones." (Female, Aerospace, Freshman)

I experience or observe <u>overt</u> sexism in my engineering discipline.

Figure 5: Female students rate the frequency of experiencing or observing overt sexism while pursuing their engineering degree.

I experience or observe <u>covert</u> sexism in my engineering discipline.

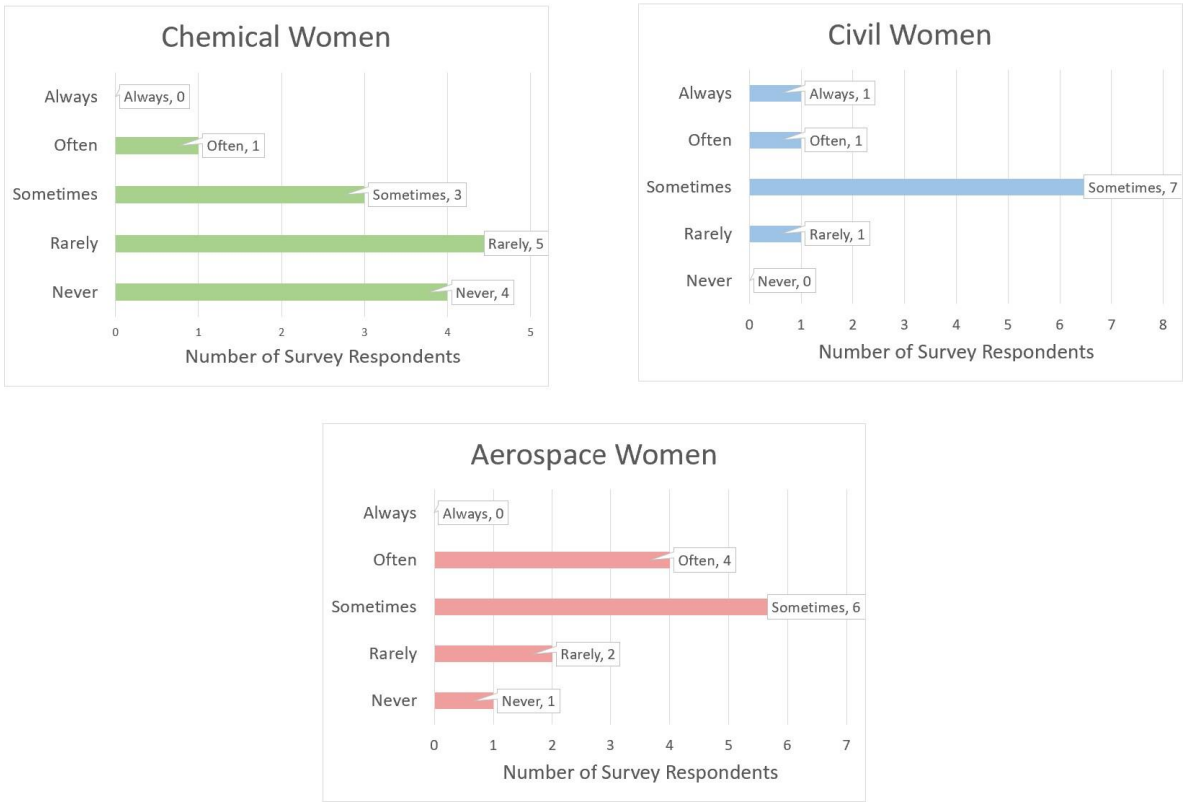

Figure 6: Female students rate the frequency of experiencing or observing covert sexism while pursuing their engineering degree.

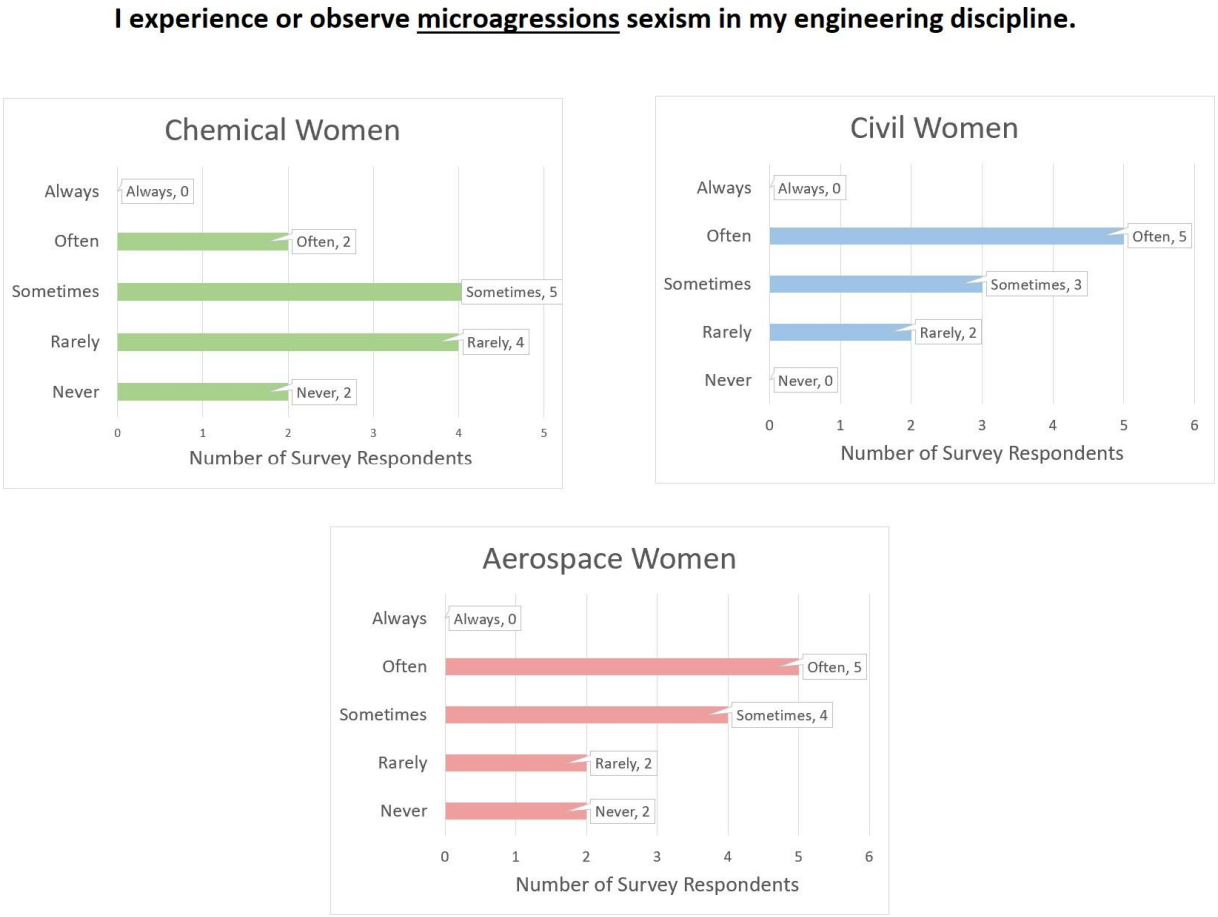

Figure 7: Female students rate the frequency of experiencing or observing microaggressions while pursuing their engineering degree.

A culture of competition was also commonly expressed by our female interview participants, consistent with the literature [4]. Two female participants reported being told they only received their internship/co-op opportunities because companies are hiring for diversity. One of our participants reported that when comparing exam and homework scores, she received shocked and frustrated reactions when she received a higher score than her male peers.

Several other microaggressions and blatant acts of gender inequality were mentioned by our female participants in the interviews. One participant stated she experienced higher expectations for her work than male students did by a male grader in one of her engineering courses. This impacted her grade and performance in the class. Another participant reported overhearing men "rate" their female classmates on attractiveness during class. One participant stated that she was often blatantly ignored when trying to contribute to group work.

42% of our female survey participants report experiencing instances of gender biases while working towards their degree. However, gender biases were commonly experienced by our female interview participants, who most commonly reported enduring a bias in engineering which pushes them towards non-technical roles in groups. One participant stated,

> "I would say as a female, I don't get to take part in the experiment [lab] itself, but then all of a sudden when we are writing the lab report I'm expected to write so much more, and they're [male lab partner's] reasoning is because their responsibility is to do the experiment so I should write the report, but I feel like that's because I'm a female that they're making me write all this, which is very annoying." (Female, Civil, Junior, White)

It was also frequently stated by our female participants that women often lack initial confidence in themselves, making it more challenging to avoid these biases. Women reported that a male ally in the group capable of identifying bias and responding appropriately could help create a safe environment where women could feel confident in their abilities and perform to their fullest potential.

Many of our male survey participants reported experiencing reverse sexism as a type of gender discrimination. When asked about their stance on reverse sexism, 100% of our female participants stated that they believe reverse sexism does not exist, but most understood why male students felt this way. Female students argue that these feelings reflect a lack of knowledge on the purpose of these resources for women and other marginalized groups.

> "I can see where guys would be coming from because I know a lot of them aren't educated on what women in engineering face. And the reason that we have [intervention] programs is because we have to build those sorts of communities to retain women in these majors. I think a lot of men think that we're getting special opportunities out of those kinds of programs and that's not necessarily the case. You may have connections, but you still have to go talk to that person and apply to internships and such. Just like you would if you went to the career or anything." (Female, Aerospace, Junior, White)

4.1.3. Feelings of Isolation and Inadequacy

Figure 8 shows that 47% of women report feeling some degree of isolation in their engineering classes, while Figure 9 shows that 75% report being treated as incompetent while working towards their engineering degree. One of our interview participants commented,

> "I got asked in a job interview once if I knew how to use a hammer when it was for a shop tech job, where I would be using tools. And I was told by the interviewer that I had a good chance of getting that job, because I was a woman, and it would look good for that department." (Female, Aerospace, Junior, White)

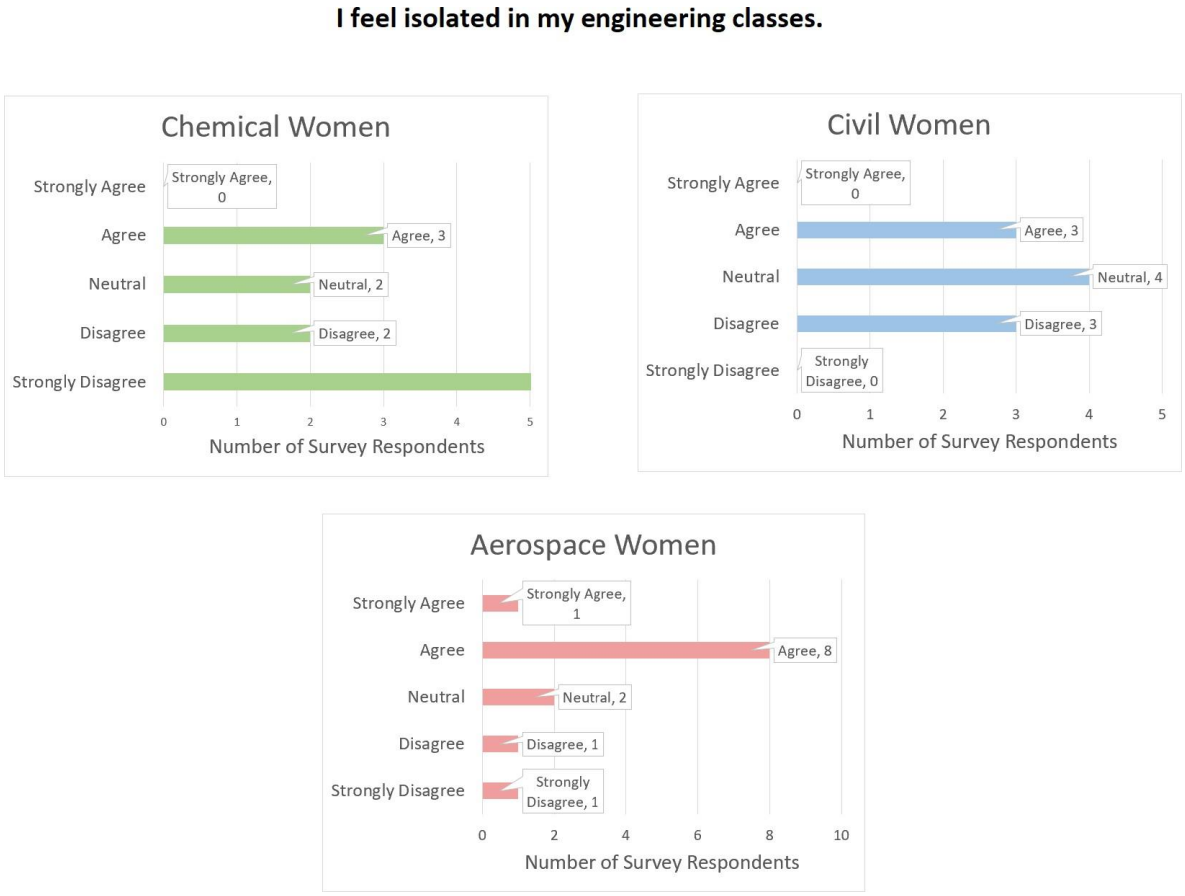

Figure 8: Female students rate the degree to which they feel isolated in their engineering classes.

Figure 9: Female students participants rate the frequency of being treated as if they were not competent while working with peers.

The literature shows that women pursuing engineering often receive negative messages regarding their abilities [1]. Our female interview participants acknowledged this and indicated that a common outcome is that women are often pushed towards non-technical roles in group projects. Our results show that 44% of our female participants are sometimes or often denied the opportunity to participate fully in group projects, as shown in Figure 10. A survey participant also mentioned imposter syndrome, a common feeling of self-doubt that women in STEM experience.

> "I feel imposter syndrome in leadership roles because my male peers sometimes make it seem I have only gotten this position because of my sex." (Female, Aerospace, Senior)

I am denied the opportunity to fully participate in group projects based on my gender identity.

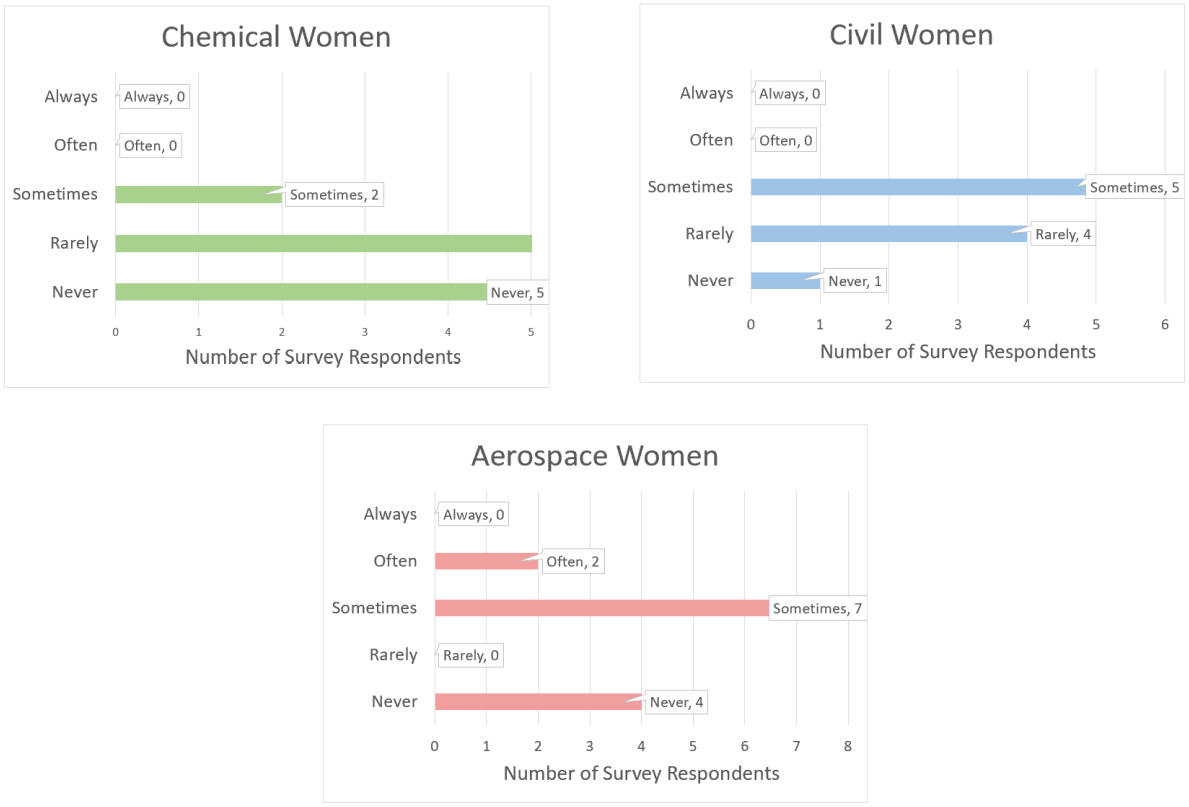

Figure 10: Female students rate the frequency of being denied the opportunity to fully participate in group projects.

4.2. Findings from RQ2: What is the male-student perception of the culture climate in engineering education?

4.2.1. Reverse Sexism

One perspective that came up when surveying men about gender inequity in their engineering disciplines was "reverse sexism", or discrimination against men. Many of our male survey participants reported experiencing reverse sexism through scholarships, resources on campus, and job opportunities. The following is a collection of quotes from our male survey participants about their experiences:

> "The inequality I have experienced is in scholarships. There are many scholarships that are given specifically to women, keeping me from the opportunity of achieving these scholarships." (Male, Aerospace, Freshman)

> "Due to the mass amount of males in STEM it is apparent that the faculty and university care less about our [male] success in comparison to the female population due to their lesser

numbers. I understand this bias. However, to say this isn't blatant sexism is to discredit the sexism women have faced forever. I feel we can't defeat sexism with more sexism as that creates hate and discourse." (Male, Aerospace, Sophomore)

"There is no Men in Science and Engineering club at our university. There are no scholarships given to specifically men going into STEM. Many of these institutions meant to drive out inequality simply add inequality in another area- less opportunity. There will be a subset of young men who decide not to pursue an engineering degree because the cost of a four-year degree didn't seem worth it. There will also be a subset of young men who drop engineering because there was no structured support group, despite the existence of Women in Science and Engineering Programs seemingly implying that there is a similar structure for males. There isn't, so I fail to see how it is conducive to the long-term wish for there to be as equal of an environment for both genders as possible." (Male, Aerospace, Freshman)

"With so many looking to hire on females in order to be politically correct, I feel some women are hired purely due to their gender status. Due to a majority of engineers being men, to tip the scales they hire women to make it equal. Women make up a small part of engineering students, yet so many are seen getting positions. So, it could be argued that it is not purely due to their knowledge or experience, but rather a focus (consciously or subconsciously) on the fact they are women. So I feel it is difficult because women get more opportune chances for work and positions than guys do, as they [men] are not judged on gender, only on their skills and knowledge." (Male, Aerospace, 5th Year Student)

"All people are equal under law, but some people feel white men in engineering are 'privileged'." (Male, Aerospace, Sophomore)

However, the subset of men who participated in our interviews expressed different views on reverse sexism than most males who just participated in the survey. All our male interview participants stated they did not believe in reverse sexism and had not been impacted by it. All interview participants generally held the stance that the opportunities provided by these minority-specific organizations promote equity and are beneficial for the advancement of women (and other minority groups) in STEM-related fields. Further, participants expressed that based on the classroom demographics, there is no need for similar resources for men.

"The purpose of those specific organizations is to bring the minority out of the majority." (Male, Aerospace, Freshman, White)

One participant expressed support for these organizations with the following quote, suggesting that the opportunities provided by these organizations promote equity by bridging the statistical gap in opportunity:

"It's just a statistical fact still. . . So, yes, I feel like it's important that women have these extra opportunities, especially because they're a smaller group within the engineering community." (Male, Aerospace, Freshman, White)

While none of our interview participants reported they had been impacted directly by reverse sexism, two participants did empathize with those who do feel impacted, stating:

> "Absolutely. I felt that way initially, but then I realized that men have had the reins on our social order since basically time began. So, I mean, I feel like it's definitely a good thing that women are given, I guess, 'extra chances'." (Male, Aerospace, Freshman, White)

> "However, I do understand the frustration from not having resources that other people do." (Male, Aerospace, Sophomore, White)

Two of our male participants reported being told that companies are currently hiring to fill diversity quotas. One participant stated,

> "I was told by my sister [who worked in engineering] that I was choosing the worst time to go into engineering because companies are hiring for diversity." (Male, Aerospace, Sophomore, White)

However, he reported never being impacted directly by this. Another participant reported being told something similar by his father, who worked in the engineering industry,

> "He said that a lot of time people would get hired to fulfill quotas, diversity quotas rather." (Male, Chemical, Junior, White)

He expressed that he believes this happens but stated,

> "Even though every once in a while, somebody might get undercut to fulfill a quota, it's not going to happen enough to seriously impact my life." (Male, Chemical, Junior, White)

4.3. Findings from RQ3: Is there a disconnect?

Our study found a clear disconnect between the male student perception of the cultural climate for women and how women experience the cultural climate across engineering disciplines. This disconnect shows a lack of awareness of the issues women face while working towards their engineering degrees. Figures 11, 12 and 13 highlight examples where female students endure negative experiences more frequently in reality than their male peers perceive them to.

To further investigate this disconnect in our interviews, we asked our interview participants, "If more men understood the extent/prevalence of gender inequality in engineering, could this help cultivate a more inclusive environment in engineering education?" All female interview participants gave a definitive "yes," but we received varying responses from our male participants.

Many of our male participants believed *that* if more men understood the experiences of women in engineering, it could have a marginal effect on inclusivity in engineering. One participant mentioned that if more men were educated on how minority groups were marginalized in the past, and how these resources advance them in STEM, fewer men would attack these minority group-specific resources.

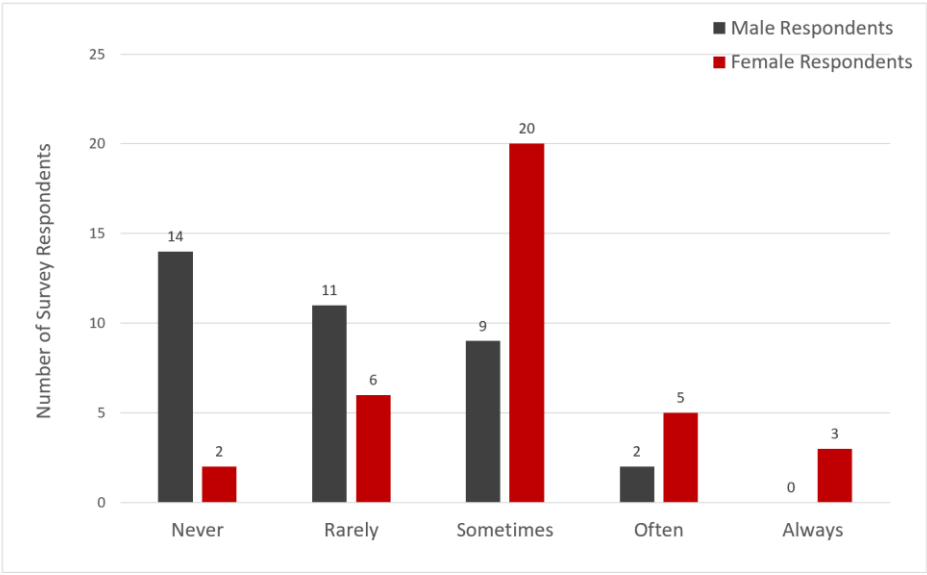

Figure 11: Male students show a disconnect in understanding the frequency to which their female peers endure sexist comments.

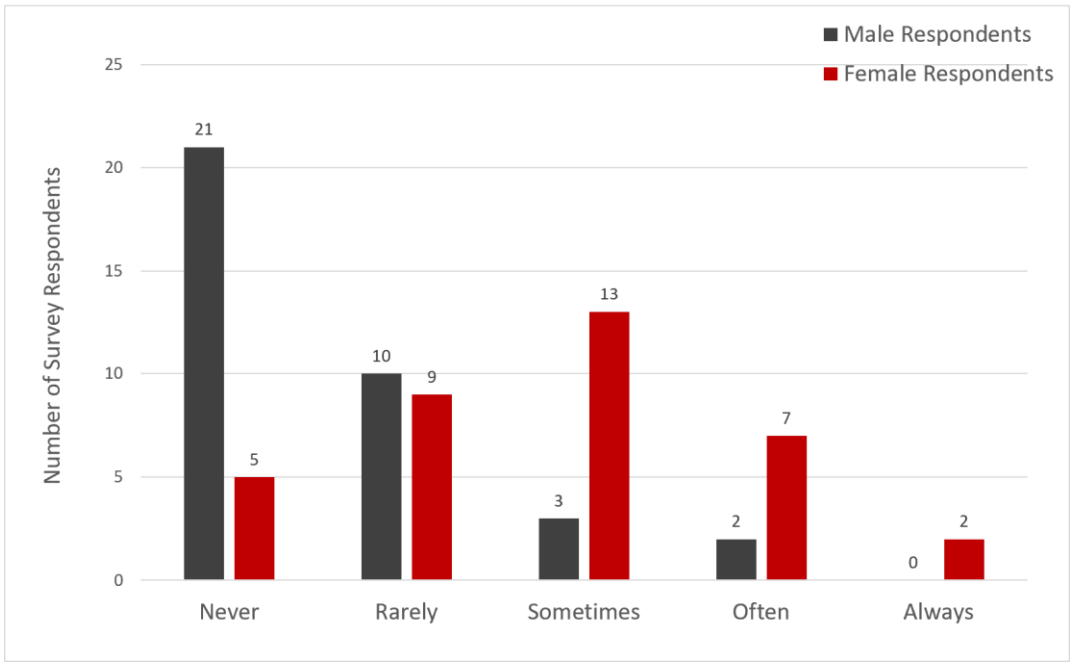

Figure 12: Male students show a disconnect in understanding the degree to which their female peers feel alienated in their engineering programs.

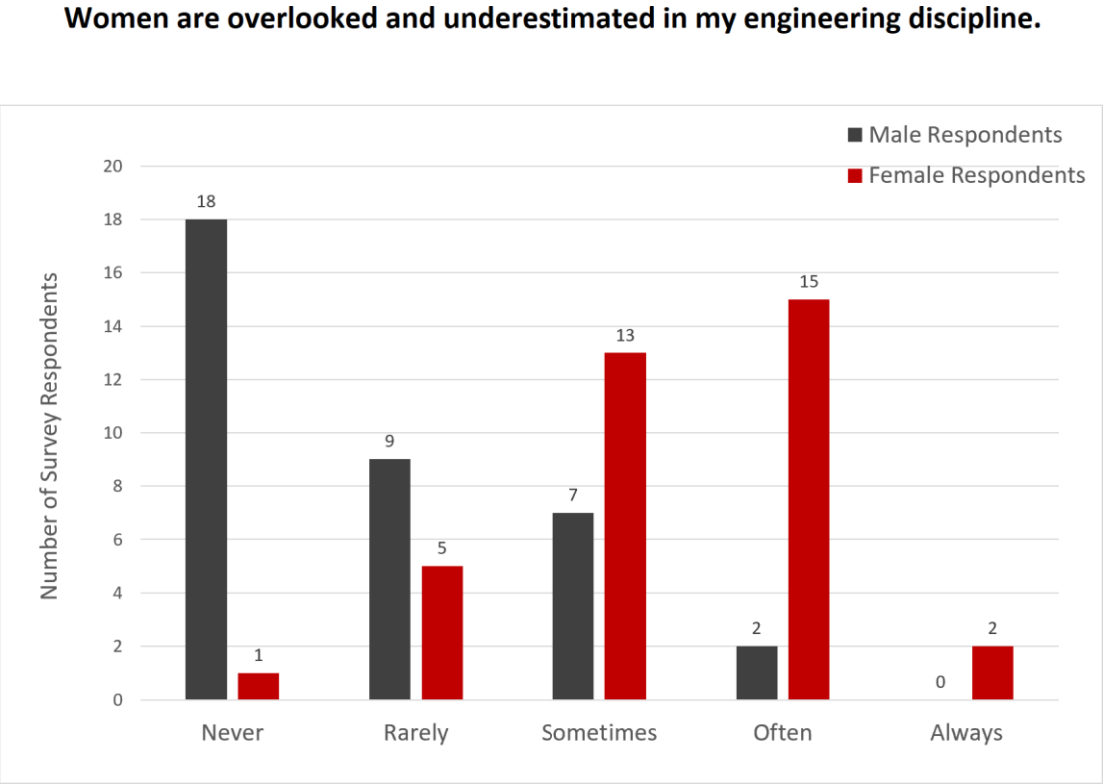

Figure 13: Male students show a disconnect in understanding the frequency to which their female peers are overlooked and underestimated in academic group projects.

One of our male participants shared a story of how he had just recently been made aware of the negative experiences of one of his female classmates. He described how, prior to this event, he had never observed any of his female classmates experience gender inequity. When the time came to register for classes, he noticed that women were being warned to avoid taking a class with a professor who had a history of inappropriate behavior towards women. He noted that since this was his first time observing gender inequity in his engineering program, he was not sure if he understood the extent of it.

A few of our male participants echoed that upon hearing their female colleagues recount their experiences related to gender inequity, they were shocked at what they had experienced. They reported that understanding their female colleagues' experiences helps empower them to be mindful of their own actions.

One of our participants expressed a gender-blind perspective, consistent with Sattari and Sandefur's study [9]. While agreeing that an understanding of female students' experiences could cultivate a more inclusive environment in engineering, he cautioned that the conversations surrounding gender inequity could negatively impact equity and inclusion efforts.

> "Having information like that plastered everywhere throughout campus is just detrimental to the way people are. People should think about treating other people right, no matter their sex. It makes people do math in their heads about 'Okay, what should I do here versus what should I do there' and that creates a divide between genders, and it is just detrimental overall." (Male, Aerospace, Freshman, White)

4.4. Findings from RQ4: What are the recommendations from students for meaningful interventions to gender-related issues in engineering education?

4.4.1. Meaningful Support Systems for Women in Engineering Education

From the survey data, we saw that our female participants have varying experiences of gender inequity, which contribute to the chilly culture in engineering. Few participants mention having only positive experiences, though one survey participant commented,

> "I have never had a bad experience because of my gender, and I have never been discriminated against either in this [chemical engineering] department." (Female, Chemical, Senior)

Many of our participants reported positive and negative experiences simultaneously when reflecting on their experiences with gender inequity. When asked to reflect on group projects she has worked on, one of our participants mentioned,

> "For every bad group, I had 2-3 good ones. So, it all makes up for it and I do have really good friends that I'm able to seek out in every class who are, if not male allies, definitely good supporters of me." (Female, Civil, Junior, White)

Another participant mentioned,

> "I have a strong will and a strong support system, so others do not bother me." (Female, Civil, Freshman)

Both quotes highlight the importance of support systems for women's success in engineering, a common theme found in the data. Our interview findings show three types of support are valued by women: (1) increased proportions of female students, (2) male allies, and (3) supportive faculty. 78% of our female survey participants and 100% of our female interview participants agreed they feel more comfortable in environments with higher female representation. Female representation can be found in classrooms with higher percentages of women or in intervention programs that give women an opportunity to get together for a common interest or cause.

Participants mentioned taking part in intervention programs like the Society of Women Engineers (SWE) and Women in Science and Engineering (WiSE) to make connections with other women in engineering since there are so few in their classes. In the classroom, when female students can work in groups, whether that be lab groups/classes/etc., where they are not the only woman, they report that they feel more safe, comfortable, and confident. Having male allies, or friends, in academic settings can further build this feeling of safety for female students. Lastly, supportive

faculty was deemed the most important factor for an inclusive classroom by our female participants. Faculty can help support inclusion through inclusive teaching practices that echo support and care for minority students. One participant described an example of these practices:

> "I've even had professors who in classes, make a point to highlight female engineers/scientists or other minority engineers, and scientists who have contributed to the topic in class. Which I thought was really cool coming from the professor who was making an effort to be like, hey, there's all sorts of people out there who you may not know about, who have contributed to this. So, it really isn't just a guy's club or a white club." (Female, Aerospace, 5th Year Student, White)

Furthermore, female faculty can provide special support for female students. Many of our female participants reported viewing their female professors as "natural advocates for inclusive environments" and "role models" in engineering spaces. Female students report feeling as though they can trust and connect with female faculty in a unique way, based on shared experiences. Because of these shared experiences, female students report being more likely to continue in engineering with their support.

When asked if they had ever reconsidered their enrollment due to gender inequity, 63% of our female participants stated they had never reconsidered their enrollment in their engineering program. They reported that their experiences with gender inequality simply "seasoned" them for what to expect when working in the industry. One participant stated,

> "I never considered leaving engineering seriously enough to take action. But there has been a couple of times where I think do I really want to spend the rest of my education and career trying to prove myself." (Female, Civil, Freshman, White)

On the other hand, 25% of our female participants reported that they had reconsidered their enrollment due to gender inequality. One participant stated,

> "It definitely made me reconsider if I wanted to actually be a part of that culture and go through with this degree, knowing that I would have to deal with that for 4 years." (Female, Aerospace, Junior)

12% of our female interview participants reported reconsidering their enrollment in engineering for other reasons.

4.4.2. Previous Education Efforts to Spread Awareness (From Participants)

63% of our female participants reported that they had not experienced educational efforts from their engineering department specifically to promote awareness of gender inequality. Those that did experience educational efforts through the university stated that the efforts were ineffective and unengaging. 12% of our female participants stated that the only efforts they have experienced were put on by organizations such as SWE or WiSE. Some examples of these efforts include presentations during club meetings, empowering movie nights, and opportunities to connect with women in the industry.

43% of our male participants reported experiencing no efforts to promote awareness and mitigate gender inequality in the classroom. The remaining 57% experienced the following efforts: (1) sexual assault training prior to attending college, (2) efforts to prevent sexual violence against women, (3) posters in classrooms and buildings on campus, and (4) female empowerment speeches in class.

4.4.3. Suggestions for Future Education Efforts (From Participants)

Discussing topics in class that highlight gender equity was the most common response from our female participants. It was suggested that professors discussing equity and ethics or discussing valuable minorities and their contributions to the field is an excellent way to bring awareness to students. Interactive experiences and discussions can also provide a more meaningful learning experience than a lackluster PowerPoint presentation on gender equity. Examples of interactive experiences provided by participants included role-playing and reverse experiences (e.g., having a male student work in a group of all female students to better understand the challenges and pressures female students face when they are the only woman in the group). It was commonly reported that most efforts to discuss gender inequities are not well-received or taken seriously by male students. A shift from standard lectures to interactive conversations is required to make the content more engaging for all students.

The following list is a collection of suggestions from our male participants on strategies to discuss topics of diversity, equity, and inclusion:

1. Add a diversity, equity, and inclusion (DEI) unit to introductory courses.
2. Make the content visible for all students to see it. Since these topics are not mandatory course curricula, not all students experience these conversations in the classroom. Visibility increases the opportunity for awareness for all students.
3. Implement documentation processes to hold people accountable for instances of gender inequality. This could help reduce the number of instances and encourage the university to take action when necessary.
4. Use role-playing experiences to better understand the challenges women face in engineering.

While agreeing that a better understanding of women's experiences could positively impact the cultural climate in engineering, one participant promoted the idea that a heavy approach to discussing these social issues is counterproductive. Describing efforts to promote awareness of the marginalization of women as stimuli for instances of gender inequality, he represented a view that these conversations create a divide between genders, making it difficult for men to want to advocate for women in engineering.

> "When all this gender equality stuff is forced on them daily, with the emails, posters on the wall, etc. it just gets exhausting. All the attention and social encouragement isolates us and turns us off from wanting to accept that it [gender inequality] is there." (Male, Aerospace, Freshman, White)

4.4.4. Suggestions for Meaningful Changes for Gender Equity in Engineering Education

The following list includes the suggestions from our female participants for meaningful actions to positively impact the cultural climate in their engineering programs:

1. Implement required trainings for professors that focus on how to best support minority students.
2. Create training focusing on diversity and inclusion and distribute to all students to be taken prior to attending the university.
3. Continued support for organizations that support minority groups, such as SWE and WiSE.
4. Increase female representation in both the faculty and student-body by increasing outreach efforts and hiring more female faculty.
5. Integrate discussions of equality and equity into the classrooms to increase the visibility of the issue to all students.
6. Reporting processes should be implemented to ensure individuals are held accountable for instances of gender inequity. Numerous participants described instances in which professors said inappropriate things in class and there were no consequences. This is discouraging to women in engineering and hinders change.

5. Discussion and Conclusion

5.1. Reverse Sexism for Men and the Culture Climate for Women in Engineering

From the results of this study, it is clear women are still experiencing a chilly cultural climate at the university level. Some men at the university level see injustices—lack of male-specific scholarships, male-specific intervention programs, and job opportunities— they consider to be "reverse sexism." However, when male students walk into an engineering classroom, they find a community where they are well-represented. Interventions such as SWE and the National Society of Black Engineers (NSBE), exist to provide this sense of community for marginalized students, which they may not find in a typical engineering classroom. Indeed, research shows that the peer networks and sense of community provided by these intervention programs can help mitigate the negative culture women may experience in their engineering departments [11]. Several of our male interview participants expressed that they did not see the need for male-specific STEM clubs on campus or other similar resources.

> "From my own experience, I've never felt like I've needed to use other extra resources. If there were to be a separate group for just men on campus in that sense, I've never seen the need for it for myself and for other guys, and especially just given how the demographics are in engineering, I think it's very important to try to offer support where there can be for women on campus. So, I guess, I have not seen a need for [male specific student organizations], and I haven't seen reverse sexism. I don't see that really impacting guys per se." (Male, Aerospace, Senior, White)

One female student argued in her interview that the perception of reverse sexism is rather an issue of "resource allocation". At the studied university, one organization that supports women in STEM provides a few semesters of free tutoring for women enrolled in STEM majors. There is no similar resource for men to get free tutoring unless the male student is enrolled in ROTC. A few of our

female student participants voiced that if men are struggling, there should be a similar resource for them to take advantage of. To address concerns of a lack of male-specific scholarship and organizations for men in STEM, men need to be made aware of the opportunities available to them and understand how these organizations that exist to support marginalized groups promote equity for minority students. Research shows that scholarships for underrepresented groups can help with recruitment, motivation, and retention in STEM fields [12].

5.2.Addressing the Disconnect between Male Student Perception and Female Experience

We argue that understanding the perspectives male engineering students hold of the cultural climate for female engineering students can drive meaningful new insights for addressing cultural climate-related issues for women in engineering. The disconnect between the actual cultural climate for women in engineering and the male student perception suggests a lack of awareness of gender-related social issues in engineering. Male students in our study reported comments which suggest they do not see the value of diversity in engineering. For example, some male students mentioned that maybe there are not as many women in engineering because it does not interest women, or that we should not push diversity into STEM fields so much because diversity does not improve the performance of a group.

In a study published by the American Sociological Review, Herring suggests that diversity can have a positive impact on business performance. Diverse groups can leverage their experiences and perspectives to solve problems and make decisions in a way that like-minded groups cannot. While some men in our study see this as diversity quotas where women are hired solely based on their gender, there is growing research that shows diversity adds value to teams and organizations. Herring's findings show that companies with medium-high levels of gender and racial diversity outperform those with low levels of diversity and are more likely to report higher-than-average profitability. Herring states, "A one-unit increase in racial diversity increases sales revenues by approximately 9 percent; a one-unit increase in gender diversity increases sales revenues by approximately 3 percent" [13]. If men can begin to understand the value of diversity for organizations, it is less likely that men will attack an initiative to hire more diverse teams.

Beyond economic value, there is also a moral case for diversity. A hyperfocus on the business case actually causes harm since it allows people to reject any moral obligation to support diversity [14]. Giacalone and Thompson describe an "aspirational approach" which centers the value of diversity around advancing the well-being of people [15]. Creating an environment where all people feel safe and included is an ethical issue that all humans should be concerned with while working toward social justice, fairness, equality, and equity.

To make meaningful changes on this front, we argue that universities need to highlight and model the value of DEI throughout engineering departments (e.g., in engineering classrooms, having a diverse faculty in engineering departments, numerous opportunities for students to learn about DEI and ethics, etc.).

5.3.Discussion on Interventions for Improving the Culture Climate in Engineering at the University Level

In our literature review, we found that meaningful support systems for marginalized groups positively impact their success in STEM [10]. These findings are echoed in the data from our study.

In our collection of suggestions for meaningful changes to increase gender equity in engineering, women argued the value of male allies, inclusive teaching practices, and intervention programs. Our study identified an additional factor for women's success in engineering: increased proportions of female students in the classroom and increased proportions of female faculty. Researchers investigated the positive influence female faculty can have on female students in mathematics and geology by reviewing women's course selection and major choice after having female professors teach their classes. The researchers found quantitative results that suggest female faculty can have a positive influence on female students, however, these results are inconclusive for programs like engineering and physics due to the small proportion of female faculty [16]. Our qualitative data suggests that most women in engineering programs view their female professors as effective role models who can provide a special sense of support that other professors cannot. At the studied university, only 19% of the aerospace professors are women, 30% of civil engineering professors are women, and 37% of chemical engineering professors are women. We argue that more needs to be done to increase the diversity of faculty in engineering departments to improve the cultural climate for underrepresented groups in engineering.

While there is little research on the impact of the proportions of female students on the cultural climate of engineering programs, results from this study suggest that women in fields with higher percentages of female students experience fewer tensions, gender biases, and feelings of isolation in their engineering programs. Further, the percentages of female faculty at the studied university reflect the low, medium, and high percentages of female students in these engineering disciplines at the studied university. This points to a trend that departments with more diverse faculty may have a more diverse student body, and this diversity can positively impact the cultural climate for underrepresented groups in engineering disciplines. However, these results are ultimately inconclusive due to the small number of participants from disciplines with greater proportions of female students.

Our study aimed to gather suggestions from students to raise awareness of gender equity and inclusion in engineering. Our results suggest that making these topics visible through carefully selected course materials and encouraging discussions about the challenges women face in male-dominated fields will provide engaging opportunities for students to reflect on the value of DEI. Our student participants gave real-world examples of professors using carefully selected course materials to highlight diversity, but many stated they were not given the opportunity to discuss these topics in class. When discussions did occur, they most often happened between like-minded people, so other perspectives were never brought to light.

Suggestions from students for meaningful changes that will positively impact DEI include required DEI training for both faculty and students; continued support and growth in intervention programs; raising the number of female students in engineering programs by increasing outreach efforts and hiring more female faculty; and take issues regarding gender inequities seriously by implementing documentation and reporting processes to hold individuals accountable for acts of gender discrimination.

6. Future Work

There is a gap in the literature regarding the impact of greater proportions of female students in engineering programs on the retention rates of women in these programs. This study looked at three engineering disciplines with varying percentages of female students to see if women in fields with lower representation experience a chillier cultural climate. From the data, it appears that women in aerospace engineering (lower representation) report feeling more alienated, overlooked, and underestimated than their chemical and civil classmates. However, given the low number of chemical and civil participants, we are not able to conclude whether women in fields with lower proportions of female students experience a less positive cultural climate than those in disciplines with higher representation. In a future study, researchers should seek to understand how increased proportions of female students impact the retention rates and experiences of women in engineering programs. Other future work should aim to understand the impact female faculty can have on female students studying engineering and how the implementation of the recommendations provided in this study affect the cultural climate for women studying engineering at the university level.

Acknowledgments

This project is based upon work supported by the Iowa Space Grant Consortium under NASA Award No. 80NSSC20M0107.

Appendix

Appendix A – Demographic Information

Table 3: Gender and engineering discipline of survey participants.

Gender	Aerospace Engr.	Civil Engr.	Chemical Engr.
Male	41	11	7
Female	14	14	19
Total	55	25	26

Table 4: Gender and engineering discipline of interview participants.

Gender	Aerospace Engr.	Civil Engr.	Chemical Engr.
Male	5	0	1
Female	5	2	1
Total	10	2	2

Table 5: Survey participants by engineering discipline and academic year.

Gender	Aerospace Engr.	Civil Engr.	Chemical Engr.
First-year	16	10	3
Sophomore	14	4	4
Junior	14	9	10
Senior	9	1	8
5^{th} year +	2	1	1

Table 6: Interview participants by engineering discipline and academic year.

Gender	Aerospace Engr.	Civil Engr.	Chemical Engr.
First-year	2	1	0
Sophomore	4	0	1
Junior	1	1	1
Senior	2	0	0
5^{th} year +	1	0	0

Appendix B - Survey and Interview Sample Questions

Sample Survey Questions

1. I feel tension from my peers regarding my academic accomplishments. Example: Good grade on a test. Tension in this case means feeling as though students are angry, jealous, or off put by your actions or accomplishments. Participants answer on a scale from Never – Always
2. I feel isolated in my engineering classes. Participants answer on a scale from Strongly Disagree – Strongly Agree
3. I am denied the opportunity to fully participate in a group project based on my gender identity. Participants answer on a scale from Never – Always
4. I feel I need to prove myself to my peers in order to be accepted. Participants answer on a scale from Strongly Disagree – Strongly Agree
5. I experience or observe microaggressions in my engineering program. Microaggressions: brief and commonplace daily verbal, behavioral, or environmental indignities, whether intentional or unintentional, that communicate hostile, derogatory, or negative messages. Participants answer on a scale from Never – Always
6. I feel more comfortable in environments with more female-student-body representation. Participants answer on a scale from Strongly Disagree – Strongly Agree
7. Women endure sexist comments and jokes while working towards their engineering degree in my engineering discipline. Participants answer on a scale from Never – Always
8. Gender inequality is an issue that women face consistently in my engineering program. Participants answer on a scale from Strongly Disagree – Strongly Agree

Sample Interview Questions

1. Tell me about your experience with gender inequality in engineering. Can you give me examples?
2. What factors in an academic setting make you feel safe and included while learning?
3. If more men understood the extent/prevalence of gender inequality in engineering, could this help cultivate a more inclusive environment in engineering education?
4. What would be a good way to discuss and educate on these topics of sexism in engineering in order to promote inclusion and develop more male allies?
5. Have you experienced any education efforts to promote awareness of gender inequality in your engineering program? If yes, what did you think about them and their effectiveness? If not, how should the department spread awareness effectively?
6. If you could have a conversation with the Dean of Students responsible for diversity and inclusion, what actions would you tell them to take to make meaningful changes to gender inequality in engineering?

Appendix C – Definitions

Gender Biases: Bias is defined as unfair treatment resulting from prejudice. An example of gender bias in engineering is women needing to prove themselves to their male counterparts to be accepted and respected. Another example is women feel the need to act more masculine in order to be perceived as competent by their male peers [17].

Microaggressions: Microaggressions are defined as brief and commonplace daily verbal, behavioral, or environmental indignities, whether intentional or unintentional, that communicate hostile, derogatory, or negative messages to or about women [3].

Overt Sexism: Overt sexism is defined as unequal and harmful treatment of women that is readily apparent, visible, and observable, and can be easily documented. An example of overt sexism in education could be purposely excluding a student in a group project on the basis of their gender [7].

Covert Sexism: Covert sexism is sexism that is either hidden and kept secret or unnoticed because it is built into cultural and societal norms. An example of covert sexism in education would be men stating that they support gender equity but then do not support intervention programs for women in engineering. In this study, stereotyping is defined under covert sexism since it is generally built into societal norms and often goes unnoticed in education [7].

Male Allyship: Male allies are capable of recognizing sexism and are willing to confront it in order to promote gender equality [18].

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