Raising their Voices:
Exploring Women's Experiences with Instruction in Engineering Courses

by

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Dedication

I dedicate this dissertation to my grandfather, Lorenzo “Lencho” Pérez who believed in the power of education. Thanks for always moving me forward. *“¡Adelante!”*

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Abstract

The presence of women and people of color in the engineering workforce is essential to ensuring a wide range of perspectives are considered as engineers engage in solving crucial problems within a heterogeneous world. Engineering programs, however, struggle to retain women and people of color thus affecting their participation in the engineering workforce. This study examined the effects of engineering instruction on the socioemotional outcomes of women students. Using a social constructivist epistemology and feminist lens, I sought to 1) understand instruction in engineering courses, 2) identify women's perceptions of instruction that made them feel included or excluded in the learning environment, and 3) understand how the learning environment contributed to women's socioemotional outcomes and how they differed by race/gender in engineering classrooms.

The study was conducted in two online, synchronous, chemical engineering courses at a large research university. A mixed-method design combined data from student surveys, classroom observations, and group interviews with students. Instructor interviews focused on pedagogical approaches and decisions. Pre- and post-surveys collected men and women students' perceptions of instruction, specifically, student-centered teaching, classroom climate (classroom bias and classroom comfort), classroom inclusivity (learning-centered environment and instructor bias) and instructor inclusivity, and three socioemotional outcomes: classroom sense of belonging, engineering self-efficacy, and desire to remain in the field. Class observations of 63 online class sessions occurred to characterize the overall pedagogical approach and triangulate data collected from the instructors and students. Group interviews, which prioritized women students, gathered data on students' perceptions to understand their reactions to instruction in these courses. Group interviews consisted of 68 student participants (organized by students' race/ethnicity and gender), and 170 student respondents to the pre- and post-survey.

Regression analyses revealed positive significant relationships between instructor inclusivity, low instructor bias, and student-centered teaching. Classroom comfort was positively related to the socioemotional outcome of classroom sense of belonging and there was a positive bi-directional relationship between post- engineering self-efficacy and classroom sense of belonging. Identifying as a woman was negatively related to pre- and post-engineering self-efficacy although women's self-efficacy increased at post-survey.

Qualitative findings supported quantitative findings and expanded understandings of inclusive teaching practices and their impacts on women. Women participants discussed entering the courses with negative beliefs about their abilities and low self-confidence due to negative past experiences with engineering peers and instructors, but most reported increased levels of confidence and capability after taking the courses. Teaching practices such as positive reinforcement and validation when students asked and answered questions, showing empathy, expressing care for student learning and well-being, and treating students with respect and in a collegial manner promoted men and women students' perceptions of instructor inclusivity. In addition, providing formative feedback and presenting relevant content increased all students' engineering confidence. For women, the relevance of course content and confidence in their learning increased their desire to remain in chemical engineering. Women also indicated that comfort with peers and instructors led to a sense of community and sense of belonging in the classroom.

The study presents a new, empirically derived conceptual framework, “The Effects of Inclusive Instruction on Women in the Engineering Classroom,” and theoretical propositions based on this framework to guide future studies. Further implications of this research are outlined, and the study concludes with practical recommendations for instructional development and other ways to improve the educational experiences of marginalized students.

Chapter 1 Introduction

Women and people of color are especially needed in engineering fields to develop products and systems that serve the needs of all people and not just dominant or powerful populations. In 2018, women earned approximately half of all science and engineering bachelor's degrees, yet there are significant disparities across the various science and engineering disciplines (National Center for Science and Engineering Statistics [NCSES], 2022). According to the NCSES, compared to fields like psychology and biological sciences which have the highest number of women graduates, computer science and engineering have the lowest. Moreover, bachelor's degrees for women in computer science have significantly dropped from 27% in 1998 to 20% in 2018, while engineering has only made minimal gains in the ten years between 2008, when women were 18% of graduates, to only 22% in 2018. The 2018 data also shows that people of color have low representation among science and engineering bachelor's degree recipients (24%) and receive fewer bachelor's degrees in engineering compared to science fields (NCSES, 2022). Representation in engineering is also low in the workforce with women comprising 16% of those in science and engineering occupations in 2019 while underrepresented minorities (Black, Hispanic, and American Indian/Alaskan Native) represent approximately 20% collectively. In Blickenstaff's (2005) comprehensive review of the literature on gender differences in STEM, he found that studies on biological differences have concluded that there are no significant differences between women and men's scientific or mathematical ability. Yet, despite institutional practices designed to retain them, women continue to leave STEM fields in college and after college (Lauer et al., 2013).

The lack of representation of both women and people of color, and recent trends, are troubling for individuals and for society. The problems are particularly evident in the field of engineering where the presence of women and people of color in the engineering workforce are essential to ensuring that a wide range of perspectives are considered as engineers engage in solving a number of crucial problems within a heterogenous world. Without diverse perspectives, engineers are limited in the solutions that they can provide to society. This also seeps into the engineering workforce in which a lack of representation can have dismal effects on underrepresented populations. Examples include products built for those who are White and who are men while also not considering effects of products on marginalized communities.

Recently, AI (artificial intelligence) facial-recognition technology has been integrated into law enforcement and even more recently airports. Yet, because data sets largely skew White and male, the AI technology is much less reliable when recognizing those who have darker skin (Lohr, 2018). Most of the widely used AI facial recognition is especially poor at accurately identifying Black women. Airbags are another product that have been exclusive to other groups. When airbags were initially created, they were designed by men thus leading to both injury and death of not only women but children as well (Barry, 2019). Women's bodies were not accounted for, and it was not until 2008, that airbags were required to be tested by a female crash test dummy. Yet women continue to have a 73% higher risk of being injured in a car crash compared to men. The problem persists as automotive makers are less inclined to make substantive changes to their safety testing because of a lack of regulation that mandates they also test for the body composition of a woman.

One example of the institutionalization of racism within engineering is the history of the Cross Bronx Expressway which connects Manhattan with New Jersey and New England

(Pockock & Palin, 2021). When it was initially constructed, it displaced a large number of individuals within the Bronx but was also considered a huge advancement in engineering. Because of the congestion the expressway caused, many middle- and upper-class families moved to the North Bronx and surrounding suburbs which led to decreased property values in the South Bronx and eventual poverty. The pollution of the expressway has led to health problems, such as high levels of asthma and diabetes, of those in the community of which are majority Black and Hispanic. Racism has historically buttressed decisions in engineering that either "sacrifice" marginalized groups or ignore them. In the case of Hurricane Katrina, which caused massive devastation and death through flooding of predominately poor and Black communities in 2005, the U.S Army Corps of Engineers failed to maintain and repair a system of levees used to prevent massive flooding even though they were aware of the faulty levees (The Associated Press, 2021).

Representation in engineering is also necessary to maintain broader equity across the country. Currently, representation in the engineering workforce is not reflective of the U.S. population and within the science and engineering workforce, gender and racial/ethnic inequities persist (NCSES, 2022). Consequently, women and racial/ethnic minorities do not have access to the same advantages and opportunities in engineering as White and Asian men. The absence of women and students of color in undergraduate and graduate engineering programs contributes to the lack of representation of women and students of color in the engineering workforce, and thus to the opportunities for economic and social mobility that engineering work can afford. To resolve these inequities, it is imperative to investigate potential ways that engineering programs are contributing to the attrition of marginalized students from undergraduate programs and precluding their entry to the engineering workforce.

The research literature is replete with discussion of the obstacles women of all races and ethnicities encounter as they navigate the attainment of an engineering degree. These include a "chilly" classroom climate (e.g., Hall and Sadler, 1982; Lester et al., 2016), stereotype threat (e.g., Cheryan et al., 2017), implicit bias (e.g., Moss-Racusin, 2012), and negative interactions with peers (e.g., Grunspan et al., 2016; Robnett, 2016; Tonso, 1996). For undergraduates, such challenges can lead to lower levels of self-efficacy (the belief in one's ability to complete a task) among women students. In an analysis of survey data of 1,881 undergraduate STEM students at nine large public universities, Williams and George-Jackson (2014) found that men had a stronger sense of self-efficacy compared to women. Levels of self-efficacy also differed by majors. Men in physical science, computer science, mathematics, and engineering had significantly higher self-efficacy than their women peers.

Studies focusing specifically on women in undergraduate engineering programs have also identified disparities in self-efficacy between men and women. In a longitudinal and multi-institutional study, Marra, et al. (2009) found that women in engineering had lower levels of self-efficacy compared to their men peers as a result of feeling a lack of inclusion in the engineering community. Similarly, in a survey of 363 first-year engineering students at a large state university conducted by Jones et al. (2010), women reported lower levels of self-efficacy and expectancy for success in engineering than men; both were predictive of engineering GPAs. Marra et al. and Jones et al. also note that low self-efficacy can negatively affect persistence.

Marginalized students in engineering also appear to have lower self-efficacy compared to their White counterparts. In a survey of 197 students at a mid-size university, Hackett et al. (1992) found that Mexican American students in the sample had significantly lower levels of self-efficacy than Euro-American students. These findings of lower self-efficacy for both students of color and women compared to White men underscores the importance of understanding how both gender and race contributes to women's development of self-efficacy.

Marginalized students' experiences in engineering appear to be related to the culture of engineering schools. This culture permeates colleges of engineering and their departments and may be observed in classrooms where interactions occur between marginalized students and their instructors. In her analysis of engineering design teams, Tonso (1996) identified a culture of masculinity and gendered discourses that occurred in engineering classrooms, on student teams, and between professors and students. She observed men dominating design teams, questioning women's skill level, and engaging in sexually suggestive comments. Tonso connects these gendered dynamics to masculine norms that are commonly accepted in engineering by men peers and instructors. Classroom practices may thus contribute to the negative experiences of marginalized students in engineering.

Classroom climate in engineering can also contribute to students' socioemotional outcomes, such as women's perceptions of their skills and sense of belonging in the field. Ro and Loya (2015) found that women in engineering, especially women of color, rated their design and fundamental skills lower than men. Such disparities in self perceptions may affect retention. In her survey of women engineers, (Verdín, 2021) found that women who had stronger beliefs in their competence and performance, which she argues is congruent to self-efficacy, also had a higher sense of belonging in the classroom and major. Further, Verdín discovered that minoritized women's interest in engineering had the biggest effect on their beliefs that they could graduate with an engineering degree. Johnson (2012), in an analysis of a large national survey, found a positive relationship between academic self-confidence and sense of belonging for women of color in STEM. She also found that environments that provided both academic and social support contributed the most to women of color's sense of belonging in STEM. Creating equitable environments for women will help maintain essential diversity within engineering which is necessary to contribute to a broad range of solutions for heterogeneous populations that exist around the world.

To understand the gender gap in STEM fields, some researchers have studied women's attitudes toward STEM, backgrounds that prohibit or facilitate entering STEM, and educational trajectories (Cheryan et al. 2017). An early strand of research focused on understanding the chilly climate in STEM environments, such as the classroom, in which women felt that they did not belong and reported encounters with gender discriminatory practices (e.g., Fassinger, 1995; Hall and Sandler, 1982). Across disciplines there is evidence that suggests women experience STEM majors differently than White men, who are in the majority in most STEM majors. Dominant values in science and engineering, which include meritocracy and competition, shape disciplinary cultures and can contribute to adverse experiences of both women and people of color (Carter et al., 2019; Harding, 1991). These experiences are potentially heightened in engineering environments because of embedded masculine historical roots. Instructors and peers may be contributing to classroom environments that are isolating and marginalizing, thus affecting women's persistence. Yet there is surprisingly little research on how women's experiences in engineering classrooms affect their feelings of inclusion or exclusion and how these might affect their intentions to remain in engineering. Exploring the role of instruction and how it shapes classroom experiences in engineering may reveal how these aspects of classroom environments may contribute to women's socioemotional well-being and desire to pursue engineering majors and careers.

Discourses and “actors” (i.e., people) within engineering classrooms can communicate cultural norms and values, such as objectivity and logic, which are perceived as masculine attributes (Gonsalves, 2014; Hartsock, 1983; Hottinger, 2016). Gonsalves and Simon et al. (2017) reveal in their studies that gendered discourses that occur in STEM environments, including classrooms, position women as contradictory to science because of their feminine attributes and expected gender roles. According to Haraway (1988), women did not “fit” in these scientific cultures because they were viewed as not possessing masculine qualities, such as the ability to be objective, which were believed to be required to be “scientific”. Although individuals within STEM disciplines may attempt to identify these academic cultures as gender- and race-neutral, research suggests science culture emphasizes characteristics that many in these disciplinary communities believe are possessed by White men only, such as emotional detachment and the ability to be logical, which can thus exclude women who are assumed to lack these traits (Hottinger, 2016; Traweek, 1988). Carter et al. (2019) argue that science is heavily influenced by these “ideologies that are, in fact, interpretive, and rooted in historical, social, and economic perspectives” (p. 70). They explain that the professional focus of the engineering curriculum contributes to the development of an engineering culture that excludes not only women but people of color.

Research also indicates that instructors and students who are socialized into disciplinary cultures come to value the views of knowledge and skills emphasized in their disciplines (e.g., Smart et al., 2000). In this way, instructors and peers contribute to the cultural norms that emerge in STEM classrooms. Robnett (2016) and Grunspan et al. (2016) found that peers perpetuated masculine norms in the STEM classroom that contributed to women’s decreased self-concept and reaffirmation of cultural stereotypes that men are more knowledgeable in STEM, respectively. Moreover, some research shows that both men and women instructors can engage in behaviors and teaching practices that isolate women in STEM contributing to the creation of a chilly climate for women (Lester et al., 2016). As evidenced in Hackett et al.'s (1992) study, differences also exist in the way White women and women of color experience the STEM classroom because of encounters not only with sexism but with racism.

These studies suggest that gendered divisions in STEM culture are perpetuated by people who adopt STEM cultural norms. Yet instructional choices that instructors make in the classroom can have different effects on students. For example, there is some evidence that integrating active learning in the classroom can increase student self-confidence and persistence while cooperative and collaborative learning have been shown to have positive effects on self-concept and critical thinking (e.g., Johnson & Johnson, 1989; McKeachie et al., 1986). Inclusive teaching, which focuses on recognizing the differing needs of students in the classroom can also positively influence self-confidence, academic performance, and academic engagement (e.g., Cooper et al., 2017; Hockings, 2010; McIntyre et al., 2003).

Despite the emphasis on chilly classroom climates, there is limited research that examines how instruction may affect experiences that women have in their science and engineering courses. Studies of the impact of teaching practices are thus a potential key to understanding the persistent gender gap in the field since a marginalizing classroom environment and the underestimation of women's academic ability by instructors can negatively influence persistence in an engineering major (e.g., Blickenstaff, 2005; Espinosa, 2011; Shapiro & Sax, 2011). Few studies within STEM contexts focus attention on the effects of teaching practices on women, and as my literature review will show, these are especially few in engineering.

Overview of the Proposed Study

I have argued that it is important to examine the engineering classroom to understand how the field's unique disciplinary culture and historical exclusion of women and people of color may affect women's classroom experiences. Studies across disciplines indicate that faculty/student interaction inside and outside the classroom can have an effect on student's educational values, academic skills, academic self-concept, persistence, and graduation and that differences exist according to gender and race/ethnicity (e.g., Kim, 2002; Pascarella & Terenzini, 2005; Pascarella et al., 2011; Sax, 2008). Studies in STEM fields specifically indicate that instructors can influence sense of belonging, self-efficacy, and persistence for both women and people of color (e.g., Lester et al., 2016; Ong et al., 2011; Rainey et al., 2018; Riegle-Crumb et al., 2020; Stewart et al., 2020; Winterer et al., 2020). In this study, I examine how classroom experiences of instructor's teaching practices affect women's engineering self-efficacy, classroom sense of belonging, and desire to remain in the field. These socioemotional outcomes have been studied in STEM fields but very little is known about their effects in engineering. Such studies may identify ways to improve learning experiences for women and people of color and address the broader and systemic issue related to engineering attrition. Successfully educating engineers from diverse backgrounds is necessary to find diverse engineering solutions to a complex and changing world and to ensure equitable access to engineering occupations.

My study will be guided by the following overarching question:

How does instruction and interactions in an online engineering course affect women's[1] *engineering self-efficacy, classroom sense of belonging, and desire to remain in the field?* To answer this question, I will address these sub-questions:

1. What is the nature of the learning environment the instructor plans to establish and enacts during the course?
2. How do students perceive the instruction provided?
3. a. How do students perceive the learning environment?

   b. How do perceptions of instruction influence their perceptions of the learning environment?
4. How do students' perceptions of the learning environment relate to students' engineering self-efficacy and course sense of belonging?
5. a. How does engineering self-efficacy and course sense of belonging relate to desire to remain in the field?

   b. Do perceptions of the learning environment, engineering self-efficacy, course sense of belonging, and desire to remain in the field vary by gender?

   c. Do these vary for women based on race/ethnicity?

Overview of Methodology and Methods

This mixed-method study involved the gathering of data through group interviews, interviews with the instructor, classroom surveys, and observations. Because of the onset of the COVID-19 pandemic, all the data was collected online utilizing video conferencing technology. I conducted the research in two different online synchronous classrooms at a selective research

[1] For this study, the term "women" includes all students who identify as women of any race/ethnicity. When reporting data from the studies, I use the authors' terminology.

university. The university has a strong focus on research and was selected because it was assumed that there would be a strong academic culture that shaped the classroom experiences of undergraduates. Yet studies have identified differences in students' perceptions of climate, curriculum, and instruction across engineering subfields (Ro & Loya, 2015). Lord et al.'s (2019) large-scale longitudinal study used transcript data from engineering undergraduates at 11 universities to examine sub-field differences in gender and race/ethnicity. For example, they found that 53% of women that started in electrical engineering did not graduate with an electrical engineering degree because they either switched engineering majors, left the major, or left the institution. In contrast, chemical engineering, a major which enrolls a higher percentage of women, had a higher migration yield (the attraction and graduation of students within and to engineering disciplines) than electrical engineering. Within chemical engineering, the migration yield of women of all race/ethnicities was higher than men. Statistics like these suggest that it is important to consider the engineering sub-discipline when conducting this type of study. I selected two chemical engineering courses for this study because the chemical engineering major has one of the highest percentages of women and students of color compared to other engineering disciplines in this university.

The two courses I selected were similar to traditional classrooms in that they were primarily lecture-based, but the instructors also integrated some aspects of active learning such as zoom polling, small group work, and think-pair-shares. I observed both classrooms online to characterize the overall instructional approach and conducted virtual interviews with the instructors at the beginning and end of the course. To gather data on students' experiences in these courses, I conducted virtual group interviews with students (with groups based on race/ethnicity and gender) in the latter part of the semester and administered an online pre- and post-survey to all students in the course.

These methods allowed me to understand the perspectives of students in the classroom, but my primary focus was on the experiences of White women and women of color. This gave me the opportunity to center the voices of women students. In my research, observing women in the classroom, interviewing them, and surveying them revealed how gendered and racialized systems of oppression operate in engineering courses and how teaching practices create environments in which women feel excluded and unsure about their abilities or cared for and capable of being engineers. Pairing the quantitative and qualitative data helped identify specific aspects of the classroom experiences of White women and women of color that contributed to their engineering self-efficacy, classroom sense of belonging, and desire to remain in the field.

Significance of the Study

This research is critical to identifying how teaching practices support women in engineering classrooms. It provides insights into how engineering culture can create isolating experiences for women, which must be rectified if engineering programs are to both attract and retain women. The study also contributes to the literature on undergraduate engineering students' experiences in their academic programs through the use of feminist perspectives and methods that illuminate the classrooms experiences of women and that are action oriented. In addition, the study contributes to the scholarly work on online courses, which examines outcomes such as grades but currently neglects socioemotional outcomes. More research on online classrooms is especially important as the COVID-19 pandemic necessitated a shift to virtual learning of which the repercussions have not yet been completely assessed.

Importantly, my research places the onus on engineering departments and instructors to improve classroom environments so they provide targeted support to women and counteract deficit narratives regarding women's skills and abilities. Conversations around creating diverse, equitable and inclusive spaces are necessary. Engineering continues to need people with diverse vantage points to address world challenges such as climate change, political turmoil, economic disparity, and the risks of global pandemics. Creating inclusive classroom experiences for marginalized populations can impact their decisions to stay in engineering majors and the engineering workforce. Although STEM support programs for marginalized students have proven to be beneficial (e.g., Maton et al., 2016; Morton & Beverly, 2017; Ramsey et al, 2012), they do not reach all students or influence the instruction students are receiving in the classroom. Improved classroom environments, coupled with academic and social support programs, are likely to have an increased impact on the retention and success of marginalized students.

Finally, this research provides a research design and an empirically derived conceptual framework that can be replicated in engineering and other STEM programs to understand how teaching contributes to women's experiences and identify ways to support women's persistence toward discipline-specific STEM careers. In addition, the findings from this study suggest recommendations for engineering instructors and administrators to consider when designing classroom environments that create equitable learning conditions for women and that can also have a positive impact on all students regardless of their background.

Overall, studies of instruction in engineering classrooms can yield understandings regarding teaching practices that contribute to women's attrition or retention and thus identify potential solutions to gender inequities. By further understanding dynamics in the engineering classroom, we can determine how to create interventions that alleviate marginalization and oppression that women encounter in engineering. Solely focusing on increasing the number of women in engineering may not solve the problems of exclusion women experience in engineering based on cultural norms that “other” and exclude them from engineering spaces.

Chapter 2 Literature Review

Although there are no significant differences between undergraduate women and men's scientific or mathematical ability, women leave science, technology, engineering, and math (STEM) majors at higher rates than men, even when they are performing well academically (Cheryan et al., 2017). Research suggests that sociocultural barriers because of an exclusionary environment may be one of the primary obstacles for both women and people of color in STEM, especially in physical science fields such as physics and engineering (e.g., Barthelemy et al., 2016; Gonsalves, 2014; Johnson, 2019; Lester et al., 2016; Simon et al., 2017). Research also indicates that this exclusionary environment can have several negative effects on women and people of color in STEM fields including their socioemotional well-being and doubts about their academic abilities. Studies have found these beliefs can specifically affect students' self-efficacy and sense of belonging. Negative academic and socioemotional beliefs and feelings thus can contribute to students' desires to leave STEM majors and careers.

Overall, my study seeks to understand the effects of instruction on White women and women of colors' classroom sense of belonging, engineering self-efficacy, and desire to remain in the sub-field of chemical engineering. Although I focus on instruction, the effects of peers on women could not be avoided. In this review of the literature, I include potential effects that peers can have on women's socioemotional outcomes because they are present in classrooms and contribute to the perceptions of the overall classroom climate. Accordingly, I will first discuss the role of instructors and peers and the ways they may create a "chilly climate" for women and people of color in classrooms across disciplines. Second, I review studies that reveal the potential effects of instructors and peers on women and people of color in the STEM classroom context. Existing research on students of color, however, does not always disaggregate by gender, making it difficult in most cases to discern the experiences of women of color. My review thus includes studies of people of color generally to identify some of the challenges women of color may encounter in STEM fields. Third, I argue that aspects of STEM disciplinary culture may actively exclude women and people of color. Lastly, I consider the effects of instructors, peers, and different types of instructional methods (specifically, active, cooperative and collaborative, and inclusive teaching) on women and people of color in STEM.

Although the current research presents a wide range of factors that contribute to women's experiences in engineering, I argue in this chapter that more research is needed to understand the effects of instruction in engineering classrooms on women. In the literature, few studies of gender in undergraduate engineering classrooms exist, and those that study gender either do not include people of color or do not disaggregate people of color by gender. Many studies also utilize either quantitative or qualitative methods and I argue that a mixed method approach to studying gender in the engineering classroom may provide more insight into the experiences of women.

Online Classrooms

As my study was conducted in an online environment because of the COVID-19 pandemic, it is possible that this may have influenced my findings. Yet, according to the literature, it appears that studies in online environments mainly focus on grades instead of instructional factors, which is the focus of my study. In studies that compare STEM online course and face-to-face courses by measuring grades, some researchers have found that students perform worse in an online environment (e.g., Bir, 2019; Faulconer et al., 2018; Sharp et al., 2017). Still other researchers have found that the differences between online and in person courses in STEM are negligible (Nennig et al., 2020). The research is further limited in that few have examined the effects of race and gender on students in online and face-to-face instruction (e.g., Amro et al., 2015; McCarty et al., 2013; Yang et al., 2015). The studies that provide evidence of differential effects of race and gender in online and face-to-face courses also focus on differences in performance (measured by grades), rather than studying instructional factors that contribute to outcomes. Therefore, I will not be covering these articles in depth in my literature review because I feel that they add little value to the conversation around instruction and women's socioemotional outcomes. All the studies I encountered focused on academic performance (grades) in an online environment rather than student's experiences with instruction. After reviewing this literature, I recognized this as an opportunity for my research to fill the gap in online instruction and the effects on women's socioemotional outcomes.

Studies of Faculty, Student, and Peer Interaction across Academic Disciplines

Current research continues to demonstrate that both peer-to-peer interaction and faculty/student interaction in college can lead to academic and personal development as well as shape the college experience (e.g., Astin, 1993; Pascarella & Terenzini, 2005; Pascarella et al., 2011). Persistence and graduation may also be affected by the kinds of interactions that students and faculty have with each other (Pascarella & Terenzini, 2005). Particularly evident is the way that interactions with faculty inside and outside the classroom as well as peer interactions can contribute to a climate that affects the experiences of women and students of color. In this section I examine faculty/student interaction in and outside the classroom context as well as peer interaction in classrooms across disciplines and the academic and socioemotional effects on students. Second, I focus on these effects as the result of in classroom student/faculty interactions and peer interactions.

Hall and Sandler (1982), in their analysis of empirical studies, reports, and surveys at the postsecondary level, discussed how faculty attitudes and behaviors toward women may reinforce social beliefs about women thus making it more difficult for men, especially, to have positive interactions with women and to view them as equals. They explained that both subtle and overt discrimination from professors as well as peers contributes to a “chilly climate.” Both verbal and nonverbal behaviors, Hall and Sandler concluded, contribute to a classroom climate that places women at a disadvantage compared to men.

In general, studies of faculty/student interaction – inside the classroom or outside – can positively affect educational values, academic skills, academic self-concept, persistence, and graduation of students (Kim, 2002; Pascarella & Terenzini, 2005; Pascarella et al., 2011; Sax, 2008). For example, Kim and Sax (2009) found that in general, students’ perceptions of positive interactions with a faculty member were positively associated with critical thinking skills.

In addition to academic skills, academic self-concept can also be affected by faculty/student interaction. Sax (2008) and Sax et al. (2005) found that support and interactions with instructors outside of class contributed to positive increases in students’ confidence as scholars, achievers, and leaders as well as improved their emotional well-being. Further research indicates that faculty support and encouragement of students of color such as African American and Latino students is positively related to intellectual self-concept and student self-confidence, respectively (Cole, 2007; Nunez, 2009). Cokley and Chapman (2008) also found a relationship between African American academic self-concept and caring professors.

Faculty/student interaction, however, can lead to differing results for different populations of students specifically in course related interactions. Sax et al. (2005) utilized national longitudinal data to identify the differential effects of faculty/student interaction on men and women. Their sample, which was 88% White, consisted of 17,637 students across disciplines of which 10,901 were women. They found that both men and women, who perceived faculty did not take their comments seriously in class, predicted higher rates of feeling overwhelmed and less satisfaction with faculty contact, courses and instruction, and the community on campus. Yet, women reported a stronger effect than men on being less satisfied with the campus community. Men also indicated at higher levels that faculty did not take their comments seriously, but the significance for women was greater than the men in that it was related to declines in self-rated physical health and mathematical ability, as well as degree aspirations.

Kim and Sax (2009), in a sample of 58, 281 students studied two different types of faculty interaction: research- and course-related, and the differential effects by gender, race, social class, and first-generation status. Course-related interactions included talking with faculty outside of class about course material, communicating with faculty by email or in person, and interacting with faculty during class. Specifically, regarding the perceived quality of course-related interactions, Kim and Sax (2009) did not find differences by gender but found numerous differences by race/ethnicity. Frequency of course-related interactions predicted higher GPAs and enhanced satisfaction for all groups except African Americans. These interactions also promoted degree aspirations for all groups except African Americans and Latinos. Lastly, critical thinking and communication was enhanced for all groups except African Americans and Whites.

This research underscores a need to further understand the effects of faculty interaction while considering the intersection of race and gender.

Whereas Sax and her colleagues studied interactions with faculty inside and outside the classroom, Fassinger (1995) focused more narrowly on the classroom environment. In her study of 51 classrooms across STEM, humanities, and social science disciplines at a small liberal arts college, she explored how class traits (i.e., classroom climate, size), student traits (i.e., confidence, preparation, comprehension), and instructor traits (i.e., approachability, supportiveness) affected student participation in the classroom. The study findings revealed differences in men's and women's self-perceptions of their participation in class. Men reported higher confidence and indicated they participated frequently in class discussions. Women viewed themselves as being highly interested and prepared in the content and discussions in class more than the men did. Fassinger found that confidence, class size, peer interaction, interest in the subject, belief that contributing comments positively affected grade outcomes, and perceptions of the emotional climate were predictive of women's participation in classrooms. In this study, professor traits (which focused on professor interpersonal behaviors) were not found to be significant with women's classroom participation. Yet, Fassinger suggests that course designs may have a greater impact on women's participation since they may facilitate peer interaction and improve the emotional classroom climate, which were variables that had a positive relationship with women's participation in class. Fassinger's study shows the potential differential gendered effects on a classroom environment and potential factors (instructors and peers) that may contribute to those experiences.

The studies presented in this section produced findings regarding faculty/student interaction inside and outside the classroom as well as peer interaction and the differential treatment, subsequent effects, and experiences of women students and students of color compared to White men, while controlling for disciplines. Because these studies include a wide array of disciplines, this approach may mask differential effects by academic discipline. Fields such as the "hard" "physical sciences (i.e., physics and engineering) have excluded women and people of color both historically and currently. Conducting discipline-specific studies in fields such as engineering is necessary to understand whether and how instruction and interactions with peers might differently affect women, women of color, and men of color, who are underrepresented compared to White men.

STEM Classroom Climate

Although there is literature on women and students of color experiences in the classroom broadly, there is a small body of research that exists which focuses on STEM classrooms. This research suggests that STEM culture is likely a contributing factor to the academic and socioemotional challenges women encounter while pursuing degrees in STEM. STEM culture can manifest through the beliefs and actions of both instructors and peers. Faculty and students for example, may believe that characteristics stereotypically possessed by men, such as logic and reason, are what make individuals successful in STEM and thus engage in practices and behaviors that are exclusionary of women who they perceive do not have these traits (e.g., Hottinger, 2016; Ridgeway & Correll, 2004). One of the areas where women may encounter such beliefs and practices is the classroom, where peer interactions, as well as the instructional choices that instructors make, can contribute to non-inclusive classroom environments.

There is evidence to show that men (instructors and peers) tend to engage in negative beliefs, biases, and behaviors toward women in the classroom, viewing other men as more knowledgeable (Grunspan et al., 2016; Robnett, 2016; Tonso, 1996). In their review of empirical studies in engineering classrooms, Murray et al. (1999) found that women students interact less with faculty, are interrupted more often than men when speaking, have their ideas dismissed more often, take on "secretary" roles in lab teams, and encounter sexist remarks and jokes more than men.

STEM culture may be embodied by instructors in the STEM classroom. As demonstrated in Lester et al.'s (2016) study, both women and men instructors engaged in negative behaviors toward women in the classroom such as inhibiting peer engagement and treating women differently than men in the classroom, often ignoring them or singling them out in the classroom. While Price (2010) found that women that were taught by women instructors were less likely to persist in STEM, other studies showed a positive effect of having a woman instructor on women students. For example, Eddy et al. (2014) found that the interaction between instructor gender and being a woman student had a positive impact on women's exam performance. Besides instructor gender, race/ethnicity of the instructor may also have a significant contribution to people of color's experiences in the classroom. Price found that African American students who took STEM classes with African American instructors were more likely to persist after the first year. The positive influence on African American students based in interaction with African American instructors suggests that students of color may be experiencing the classroom differently than their White peers and warrants further research.

Besides mixed results of the impact of the gender and race/ethnicity of an instructor on women's experiences, there is evidence that instructors of both genders can engage in instructional methods that are non-inclusive. In their ethnographic case study, Lester et al. (2016) found that instructors in STEM courses, both men and women, engaged in gender microaggressions (defined as small, implicit messages that one receives regularly based on social identity group) such as using gendered language and focusing more attention on the men compared to women in the classroom. They found that instructor's communication and pedagogy contributed to microaggressions that placed women as outsiders of STEM. Instructors that did not facilitate engagement and collaborative learning in class created what Lester et al. defined as a "masculine, hierarchical learning environment" in which the majority of microaggressions were implicit. Instructors that did not implement active learning or "mixed gender cooperative learning" isolated women from men. The study also found that due to lack of peer interaction, women felt they could not talk to anyone about the course content, which contributed to their isolation in the STEM classroom.

Lester et al.'s (2016) ethnographic study demonstrates the potential role of instruction in influencing the experiences of women in STEM classrooms. In their study, Lester et al. relied primarily on observations from six classrooms and interviews with nine women who experienced microaggressions in their classrooms. Because this study did not attend to additional social identities of the women participants, it reveals a need to understand if there are differences in the experiences of White women and women of color in STEM classrooms. Also, interviewing students who did not experience microaggressions could be useful to determine if they have experienced microaggressions but do not recognize them as such. Attitudes about microaggressions may reflect an embedded STEM culture where microaggressions are tolerated.

What instructors in STEM do in the classroom may also be a contributing factor to the academic performance of women. In an analysis of longitudinal data at the University of Michigan, Koester et al. (2016) examined grades of men and women in 116 large courses across disciplines from 2008-2015. They found that students in introductory STEM lecture courses on average received lower grades than in other courses in STEM, but that women received lower grades than men who had the same GPAs and test scores. Yet, in the lab environment, gender differences in grades were minimal. Koester et al. also found that courses in the physical sciences, such as engineering and physics, had larger gendered grade penalties (receiving lower grades) than other disciplines. This research might reveal that instructors in STEM disciplines grade women differently than men, but the authors considered stereotype threat (a self-evaluative threat as a result of negative stereotypes about one's group; Steele & Aronson, 1995) as a possible explanation for the lower grades that women received given that the academic records (high school GPA, university, GPA, and test scores) of the women and men in the study were equivalent. A follow-up study found similar results across lecture courses in four additional universities. Matz, et al. (2017) reported that men earned relatively higher grades than women in lecture courses in biology, chemistry, and physics courses, even after controlling for the influence of prior academic achievement. This research highlights the potential role of instruction in contributing to gendered performance which merits further exploration.

This research presents mixed results of classroom level findings regarding the impact of the social identity of the instructor on women and people of color. Yet, researchers may be overlooking how instructional methods, rather than the social identity of an instructor, reflect STEM culture and may produce differences by race and gender. These studies demonstrate that there is a need to examine the effects of instruction, not simply the instructor, on students in STEM classrooms.

STEM Disciplinary Culture

STEM disciplinary culture shapes what occurs both inside and outside the STEM classroom, thus contributing to how women and people of color are perceived and treated. Understanding the general concept of culture as intangible values and belief systems (Banks, et al., 1989) provides insight into understanding how STEM culture has formed over time. The work of Haraway (1988) and Harding (1991) posits that both white supremacy and masculinity are embedded in science. They argue that White men have had a significant role in creating an academic culture that equates scientific values with White masculine attributes, thus placing women and people of color as outsiders because they are viewed as not possessing the same attributes as White men to make them successful in STEM.

Specifically, Haraway (1988) and Harding (1991) argue that science has historically developed values centered on objectivity and rationality in thought and research and has claimed as a result to be culturally neutral. Yet, these views largely represent the values of the White men that dominated western science and thus exclude the views of women and people of color. Haraway postulates that historically those in power (i.e., White men) determined that science should value objectivity, thus placing distance between the subject of research and the researcher, as a means to maintain both white supremacy and patriarchy. Harding argues that science cannot be culturally neutral since scientists must use both cultural and material resources, to which they have access, to engage in scientific practices. Additionally, she views science as deeply connected to historical and philosophical scientific practices from the past, so although scientists may claim to be unimpeded by social pressures, science is shaped by social factors.

Since culture significantly shapes the scientific inquiries that are pursued and influences the way science is conducted, Harding (1991) further argues the scientific methods that are used in science, with the goal of eliminating social influences and values, are supporting the values that are part of the predominant White and masculine culture of science. The historical institutionalized practices of science contribute to the idea that science is universal and that a person’s social identity does not influence scientific practice.

According to Ladson-Billings (2000), these dominant paradigms within science can limit the voices of those with differing cultures and identities. Kishimoto (2018) contends that the hidden curriculum in higher education is shaped by Eurocentric values and male privilege and assimilates students to dominant epistemologies around objectivity and truth, thus oppressing marginalized populations such as students of color and women. Carter et al. (2019) discuss how meritocracy, which they argue values intelligence over other characteristics, has permeated higher education creating and maintaining a social hierarchy. Ong et al. (2011) argue that the culture of STEM departments includes a structure of meritocracy that focuses on grades, classroom performance, and research while ignoring the reality of both racism and sexism in the science environment.

Carter et al. (2019) explain that before the twentieth century, meritocracy was used to create a racial hierarchy in which people of color were treated inhumanely because they were viewed as less intelligent. According to these authors, meritocracy does not consider structural constraints such as racism, sexism, and socioeconomic status. Therefore, those who are privileged by meritocracy do not recognize this privilege and view others that do not attain the same educational status as lacking talent or ability. Carter et al. explain that STEM majors and occupations are perceived as high status and therefore represent meritocratic ideology since they do not consider aspects of individuals' identities such as race, gender, and economic status. Cech (2013) argues that in engineering, meritocratic ideology holds that intelligence is something that you are born with rather than something you can gain. Engineering, she argues, is riddled with meritocratic regimens that include such common practices such as grading on a curve and "weeding" out students in courses, which is the process of removing students from courses who are perceived to not be "smart enough" to do the engineering coursework.

Farrell et al. (2021) observe that engineering culture is characterized by elitism through practices of epistemological dominance (devaluing other ways of knowing), majorism (placing higher value on STEM over the liberal arts), technical social dualism (the belief that issues of diversity, equity, and inclusion should not be part of engineering). In this cultural context, marginalized populations such as women and people of color experience stereotype threat, the psychological effect on identity groups based on negative stereotyping. Kuzawa (2017) points specifically to engineering curricula as manifestations of values that shape the behaviors and attitudes of both students and instructors.

Similar to Farrell et al.'s (2021) notion of technical social dualism, Cech (2013) argues that engineering is marked by depoliticization, or the assumption that because engineering work should be objective it cannot consider social justice concerns and thus isolates students for whom these concerns are central. The ideologies of meritocracy and depoliticization can thus affect the persistence of both women and people of color in spaces such as engineering classrooms because their concerns and/or cultural backgrounds are not validated by instructors or other peers which reproduces inequality.

Moreover, microaggressions against women and people of color can especially occur in engineering classrooms and departments thus further contributing to a negative overall campus climate (Carter et al., 2019). As a result, Carter et al. argue that both women and people of color are less likely to persist in engineering than White students, despite having the same grades and test scores. Pawley et al. (2016) suggests that more research is needed to understand how the gendered nature of engineering culture infiltrates the classroom as this is a topic that is frequently discussed in the engineering literature.

Women and people of color in Engineering programs are also subjected to a socialization process that encourages conformity to social norms. Johnson (2019) found that Black and Latinx engineering students at a Predominately White Institution (PWI) engaged in different cultural processes as they attempted to integrate into majority White peer networks. Research in the field of physics can also provide insight into engineering because of the overrepresentation of men as well as the high value placed on the mind over the body, and how the mind is viewed as intertwined with masculinity while the body is viewed as feminine (Ottemo et al., 2021).

In her study on physics culture, Traweek (1988) found that physicists operated under a presumption that the discipline was gender neutral and did not have a culture. Yet, Traweek identified a very distinct masculine culture that promoted what were viewed as masculine traits – competitiveness and technical competence – rewarding men more than women for possessing these traits. Similarly, in her study on the experiences of three women in the physics environment, Gonsalves (2014) reveals how the masculine culture in physics diminished women's acceptance in the field. She found that cultural norms within physics ostensibly promoted gender neutrality and objectivity while reinforcing masculinity by preventing women from being fully accepted and recognized in the physics environment despite their efforts to prove technical competence and hide aspects of femininity.

Prescod-Wienstein (2020) focuses on both race and gender, arguing that whiteness shapes physics culture producing a dominant discourse of "white empiricism." She conceptualizes white empiricism as a "phenomenon through which only White people (particularly White men) are read as having a fundamental capacity for objectivity and Black people (particularly Black women) are produced as an ontological other" (p. 421). The exclusionary behaviors of White men, according to Prescod-Weinstein, deny other opportunities to contribute to the construction of knowledge in physics, particularly if their ideas do not ascribe to the social and intellectual beliefs of the dominant group. Similarly, engineering also engages in dominant discourses that actively exclude others that do not conform to the culture.

Studies of STEM culture often examine how widespread cultural beliefs about gender contribute to a STEM disciplinary culture that causes negative behaviors toward White women and women of color. Cheryan et al. (2017), Barthelemy et al. (2016), Simon, et al. (2017), and Moss-Racusin et al. (2012) all argue that a masculine science culture contributes to the lack of women in STEM. Cheryan et al. (2017) focus on the societal construction of gender as a main reason behind the gender issues prevalent in STEM culture and explain that STEM fields are influenced by society's institutionalized norms and beliefs that reward men and women for conforming to their prescribed genders. They further contend that stereotypes, which form when children first enter elementary school, continue to reflect broader societal culture which values masculinity in STEM. Commenting on their meta-analysis of empirical studies, Cheryan et al. hypothesize that persistent masculine culture in computer science, engineering, and physics contributes to the gender gap. Moss-Racusin et al. similarly refer to cultural stereotypes about men and women that are prevalent in society, such as viewing women as less competent but more likeable than men. These stereotypes, the authors argue, can shape behaviors toward women and reward men and women in different ways.

Simon et al. (2017) contributes to our understanding of how culture manifests through their exploration of how men and women are rewarded differently in STEM. Their study, which included survey data from 752 undergraduate students at a public STEM-focused research institution, measured masculinity and femininity of men and women with perceptions of academic climate (utilizing the Bem sex-role inventory, Bem, 1979). Simon et al. (2017) found that while high scores on the scale of masculinity was predictive of a decreased pursuit of a STEM degree among men, higher scores on femininity among men was predictive of STEM degree intent. In contrast, women who scored higher on femininity than masculinity had a decreased likelihood of pursuing a STEM degree. The researchers contended that femininity in men has different meanings than when it is attributed to women: whereas men who are hyper-masculine may be encouraged to pursue careers in which assertiveness is valued (sports, law, business, politics), the performance of femininity by a woman in a STEM classroom may prevent her from being viewed as a scientist thus decreasing her interest in STEM. Women in STEM who scored higher on the femininity scale reported fewer friends in their major than women with lower femininity, while men with higher femininity reported experiencing positive outcomes such as less frequent unfair treatment from a professor, more attention in class, and having more friends within the major.

STEM culture can also contribute to the manifestation of negative treatment of women through sexist behavior in STEM environments of both faculty/instructors and peers. Tonso (1996) engaged in a semester-long ethnographic study of a sophomore engineering design class and observed sexism by peers which included men dominating a group, questioning a woman's skill level, criticizing her presentation skills, and being sexually suggestive. Tonso connects these gendered dynamics in the group to masculine norms that were accepted in engineering by the men in the classroom which included peers and faculty. According to Tonso, people within engineering are acculturated into a traditional system of certain practices and beliefs that have masculine and militaristic roots. She discusses how the weed-out system in engineering in which students undergo a process of being filtered out of and into engineering reflects traditions in the military in which men had to overcome various challenges to determine who could stay and who would be dismissed. Tonso explains that because the military was focused on training men, the weed-out system adopted a masculine way of determining who belongs in engineering and who does not. Tonso's study is based solely on her observations of a classroom in which she did not interview any of the subjects to identify whether or not the women who were affected by the sexism agreed with her interpretations. The perceptions of the women encountering sexist interactions in engineering would be important to analyze to determine if the women viewed it as explicit, implicit, or chose to not acknowledge it. This would inform how the environment may need to be adapted to minimize sexist interactions.

Barthelemy et al. (2016) conducted semi-structured interviews of 21 graduate women in a physics and astronomy department and found that the environment actively excluded women through sexism and microaggressions by discouraging women's participation and persistence, dismissing their ideas, obstructing their participation in research and access to lab equipment, and conveying messages of women as objects. They also found that although more women were represented in astronomy than physics, the results indicate that women in both programs encountered equal amounts of sexism by both peers and faculty. This is particularly important to refute the argument that by merely increasing the number of women in a STEM major sexism will be eliminated. This study, however, is limited in scope; the women participants were in their later years of graduate school and were considered exceptional and successful women. Other qualified women that may have left the program and their experiences are thus not represented.

Experiences of Students of Color in STEM Programs

Because of the layers of sexism and racism evident in STEM culture, women of color (African American, Hispanic, Asian American/Pacific Islander, and Native American) are particularly vulnerable to encountering even greater challenges in STEM than White women because of the intersectional structures of oppression based on racism and sexism (Crenshaw, 1991).

In a study that included 4,800 students of color at a predominately white institution, Lee et al. (2020) measured campus racial microaggressions that STEM students of color experienced. They found that women of color experienced microaggressions at a higher rate compared to their men counterparts. When analyzing the racial microaggressions from instructors, teaching assistants and advisors, they found that women of color had an increased probability of occurrences compared to men. Students indicated that racial microaggressions occurred when they interacted with instructors such as during office hours.

Ong et al. (2011) discusses how both academic and social environments for women of color in STEM contributes to women of colors' attrition in STEM majors and careers. They attribute lack of degree attainment to the male-centric STEM climate and a lack of support from faculty and other mentors within STEM, which can influence whether or not women of color persist toward STEM degree completion.

Johnson's (2019) work provides insight into how students of color navigate marginalization in STEM culture. Johnson studied the experiences of Black and Latinx engineering students as they negotiated the culture of an elite, predominantly white institution. His analysis of interviews with 38 Black and Latinx engineering students resulted in his identification of three groups of students – integrators, marginalized segregators, and social adapters. Each was an approach to navigating engagements with White peers in an academic context. Integrators were from predominantly white high schools and associated with peer networks that were predominantly white. Although they were aware of their ethnic/racial identities, they did not experience any discomfort based on their underrepresentation. On the other hand, marginalized segregators that were from racially/ethnically diverse high schools did not feel comfortable interacting with the predominant population in engineering which was white, wealthy, and male. Social adapters, who came from different types of high schools, were able to exist in the predominantly white world as well as their ethnic/racial peer groups and were effective in engaging with their White peers. Johnson explains that ethnoracial marginalization can lead to negative outcomes for students of color which include decreased sense of belonging and self-esteem. This study demonstrates that navigating cultural aspects of engineering, which appear to be predominantly occupied by White men, can be challenging for some students of color. Further research is necessary to determine how interactions with peers in a discipline such as engineering, which is largely composed of White men, may contribute to women's and students' of color isolation, sense of belonging, and self-efficacy.

Engineering environments and the microaggressions they encourage and permit can also have negative impacts on Black and Latinx women's mental health. Cross et al. (2021) conducted a mixed-method study in which they conducted a survey and interviews of 28 Black and Latinx women in engineering over the course of an academic year. In the survey they measured engineering identity, ethnic identity, attitudes of the four stages of womanist identity development, racial microaggressions, and self-reported anxiety and depression. Findings indicated that Black and Latinx women had strong engineering and ethnic identities. They also found that women in the study identified with the first stage of a womanist identity which is conforming to social norms and not recognizing discrimination against women. For Black and Latinx women, high levels of race and gender microaggressions contributed to higher levels of anxiety and depression.

Engineering culture also has a considerable role in shaping classroom experiences for women of color because of the focus on individualism instead of the collective community. For example, the tension between engineering culture and Latinx culture is explored in Lopez et al. (2019)'s mixed method study, which employed a survey and individual interviews to understand how Latino students' experiences with science and engineering culture affected their "sense of familismo". According to Lopez et al., familismo is the cultural way Latinx people value their community over the individual. Lopez et al. found that competitive STEM culture, which counters familismo, was reinforced through large class sizes and negative interactions with instructors in STEM. Lopez et al. also found that Latinas had an even lower sense of familismo compared to Latinos. Connecting with peers by sharing notes and studying together as well as receiving care from peers and instructors were ways Latinos resisted an individualistic STEM culture in favor of familismo. This study indicates that spaces such as classrooms can have a considerable role in shaping Latinas' experiences in engineering.

Black women also encounter difficulty navigating engineering environments because of its exclusionary disciplinary culture. Blosser (2019) interviewed 12 Black women in engineering about their experiences in engineering. The Black women in the study shared feelings of isolation because they were typically the only Black woman in a course. They also discussed discomfort associated with being "hypervisible" and standing out because they were typically the only one of their race/gender in a course. Forming study groups was also an issue for many of the Black women in the study because their White peers would exclude them or ignore them. Being both Black and female contributed to the microaggressions the women in the study encountered particularly peers doubting their intellectual ability and treating them as outsiders in engineering.

Evidence indicates that STEM culture influences students' perception of issues with race and gender. Dancy et al (2020) utilized qualitative data from a larger study that included 138 STEM majors in their senior year and 45 STEM leavers who were no longer pursuing STEM. The researchers analyzed differences by gender and race in how students perceived the impact of gender and race in STEM. They found that nearly all men indicated that women did not pursue STEM because they had a lack of interest. Only women of color indicated that race had an impact on their experience in STEM whereas White men were the least likely to acknowledge the impact of race/gender on STEM experiences.

Instructor Effects and STEM Student Outcomes

Research indicates that women and people of color's experiences interacting with STEM instructors can contribute to academic performance, self-efficacy, and sense of belonging in different ways (e.g., Eddy et al., 2014; Kim & Sax, 2018; Lawson et al., 2018; Robnett, 2016). Studying these differences may further understanding of why certain interactions with instructors can contribute to negative or positive effects on STEM students, especially in engineering.

According to research, instructors may influence women and men's academic performance in the STEM classroom. Koester et al. (2016) found that women in STEM received a greater "grade penalty", or lower grades, in lecture classes compared to their male counterparts even when controlling for GPAs and test scores, which points to a possibility that the instructor may be influencing this outcome since women's grades in labs and discussions (typically taught by graduate students) were not affected. Eddy et al. (2014) found that women students who were taught by a woman instructor performed one-tenth of a standard deviation better on exams than the other women in the sample taught by men instructors; enrollment in a course with a women instructor also reduced the achievement gap between men and women by 50%. However, the researchers did not examine instruction or exam format to determine if the difference in women's performance on exams and participation was connected to instructor gender. Both studies demonstrate a need to further understand whether the instructor or the instructor's teaching practices had an effect on women's academic performance.

Self-efficacy and Persistence

Although there is a large body of research on gender differences of self-efficacy in STEM fields particularly during a course or over a period of time in the major (see Clark et al., 2021; Hackett et al., 1992; Jones et al., 2010; Marra et al., 2009; Verdín, 2021; Williams & George-Jackson, 2014), there is only a small portion of literature that places the focus on instruction and how that contributes to self-efficacy and persistence. Instructors in STEM appear to contribute to women's self-efficacy (confidence in one's ability to complete a task) as well as their desire to remain in STEM (persistence).

Stewart et al. (2020) collected data from pre-engineering students in an introductory physics course (N=1557) over two years. The researchers used domain specific subscales of self-efficacy that included current course self-efficacy, science courses self-efficacy, math courses self-efficacy, major courses self-efficacy, and professional self-efficacy (planned future profession). They also collected college GPA and student test scores. The instructors in the courses included aspects of active learning such as clickers and group work. Before course feedback through tests was administered, women reported lower self-efficacy toward the physics course they were taking compared to men yet had similar self-efficacy to men in the other domains of self-efficacy. Once women received examination feedback there was a reduction in the gap of self-efficacy, but women's self-efficacy remained significantly lower than the men.

Women of color's experiences with instruction had also been considered in the literature. Ong et al. (2011) conducted a synthesis of literature on women of color in STEM to further understand how aspects of the structural environment contributed to the experiences of women of color. They found that women of color face intersecting systems of oppression due to their gender and their race. One of the areas they found that appears to improve conditions for women in STEM is a positive relationship between students and faculty. Based on their review, they conclude that women of color's persistence are linked to the role of faculty in the classroom and their pedagogical approaches can affect women of color's participation. Ong et al. also found that relationships were important to women of color which included not only faculty but peers as well. The authors found that women of color found it difficult to form relationships with peers within their majors, so they developed relationships with peers outside of their majors that mirrored their racial/ethnic identity. Ong et al.'s study reveals that both faculty and peers may have a significant role in improving or decreasing engineering self-efficacy.

Teaching practices can also contribute to women's desire to continue in STEM. Riegle-Crumb et al. (2020), in a survey of 229 Asian and White women at two universities in chemistry and chemical engineering, measured women's future commitment to working in STEM, perceptions of agentic (being able to use skills to do enjoying work) and communal opportunities in STEM fields, and faculty/student interactions. They found that women who indicated agentic occupational affordances was a strong predictor of students committing to pursuing a STEM career. They also found that White women who had higher satisfaction with faculty interactions had higher commitment to pursuing STEM.

Regarding women of color, Winterer et al.'s (2020) synthesis of the literature on Latinas in STEM found that fourteen qualitative studies showed that instructors that were caring, engaging, invested in student learning, and personable influenced Latinas' degree aspirations and academic performance. Three studies they reviewed found that teaching practices contributed to increased interest and engagement in the course for Latinx students. Therefore, women of color need to be further researched to determine the relationship with instruction, self-efficacy, and persistence.

Sense of Belonging

Instructors may have a role in the development of a sense of belonging either positive or negative. Sense of belonging, or the connectedness a student has to their community, can contribute to positive outcomes such as persistence for students in the STEM classroom (Wilson et al., 2015). Lester et al. (2016) found that faculty in computing engaged in gendered communication and pedagogy which contributed to women's experiences of isolation within the classroom, which is an indication of decreased sense of belonging. Further evidence reveals a connection with peer and instructor interaction and sense of belonging. A quantitative study in a first-year packaging course of 85 students measured how student interaction with instructors and peers impacted sense of belonging in the classroom (Harben & Bix, 2020). Over the course of the semester, the instructors used clicker questions to encourage discussion with peers as well as set up group activities in self-selected groups. The researchers found interventions that facilitated interaction with peers and the instructor increased student sense of belonging in the classroom.

In a large cross-institutional data set of 1,355 students in introductory computing courses, Sax et al. (2018) evaluated the classroom experience, specifically examining instructors' pedagogy, instructor inclusivity, and communication with students. They found a relationship between sense of belonging and college environments and experiences, particularly faculty's role in contributing to belonging. Two environmental variables, support from the department and support from peers, positively predicted sense of belonging. Further analyses showed a positive relationship between inclusive pedagogy and students' feelings of support from the department. Overall, women entered computing with lower levels of sense of belonging in the computing course and their sense of belonging decreased by the end of the course. Yet, women of color entered computing with higher levels of sense of belonging compared to White and Asian women but lower than men of color. Further, women of color's sense of belonging did not significantly change throughout the course compared to White women.

Several studies reveal that women of color encounter particular challenges regarding their sense of belonging in the STEM classroom. According to Rainey, et al. (2018), who interviewed 201 college seniors, women of color were the least likely to have a sense of belonging in STEM compared to White men. Women of color indicated that negative interpersonal relationships with individuals within their STEM departments, including instructors, negatively affected their sense of belonging. Rainey et al.'s study considers the intersection of racism and sexism and how women of color experience the STEM environment, which is useful to identify the contributing factors that deter women of color from science.

Lee et al. (2020) found that Black and Latinx students indicated not feeling like they belonged because of racial microaggressions they encountered because of a lack of representation, such as being mistaken for being in the wrong class. Both Black and Latinx students shared that White and Asian students did not want to work with them in groups because they viewed them as unintelligent, a negative stereotype attributed to students of color in STEM. Johnson's (2012) analysis of data from a large national survey that included 1,722 women in STEM areas sought to understand the experiences of women of color associated with sense of belonging. She found that being a woman of color had a negative relationship with sense of belonging. She also found a relationship between academic self-confidence and sense of belonging, and that academic and socially supportive environments were the strongest contributors to sense of belonging of women of color in STEM.

Verdín's (2021) study of women in engineering (n=373) across nine institutions in the United States offers further evidence of the influence of peers on sense of belonging for minoritized women. She separately analyzed the data by placing minoritized women in engineering in one group and majority women in engineering, who identified as White, in another group and explored the relationship of classroom belonging and women's persistence beliefs. She found that majority women's sense of belonging was only moderately influenced by outside recognition. But for minoritized women, receiving outside recognition from instructors and peers contributed to their sense of belonging in the major and the classroom, which is consistent with the literature that indicates instructors and peers have a pivotal role in contributing to classroom sense of belonging. Yet, minoritized women also reported receiving lower levels of recognition from peers and instructors compared to majority women, thus, suggesting the importance of both instructor and peer support for women of color in engineering.

Effects of Peers on Women in STEM

Peers within the STEM classroom environment can also contribute to the "chilly climate" that some women experience. Peers, like faculty/instructors, can engage in negative behaviors such as sexism and bias toward women in STEM. As a result, these behaviors toward women can influence women's engagement and academic performance. All these variables can negatively contribute to student persistence in college and in a STEM career.

In a mixed methods study involving survey data from 2,783 students in 73 introductory science STEM courses across 15 different institutions and focus group data from 241 students across eight universities, Gasiewski et al. (2012) found that positive, collaborative interaction with peers positively predicted students' levels of engagement in STEM courses. Examining the effects of gender ratios on students in a first-year biology course, Sullivan et al. (2018) in a quantitative study, found that increasing the number of women in small groups in a classroom ameliorated the performance of both men and women. They also found that women evaluated themselves and others more critically than men did.

Disciplinary differences in the way women are treated may be more prevalent in fields such as engineering. Fairlie et al.'s (2020) study reveals that females were not academically impacted when paired with men in a chemistry course. In the study, the researchers randomly paired students over a four-year period in an introductory chemistry lab to determine if females' academic performance was affected. They included four academic outcomes: final scores in the course, final letter grade, whether the student passed, and whether the student dropped the course. They used scores in a previous chemistry course as a control and to identify low and high-ability students. Females on average performed better than males in the course and their academic performance or their long-term interest to stay in STEM was not affected whether they were with another female or a male. Male students' academic performance or interest in STEM were also not affected when paired with a female.

This research, although limited, emphasizes how peers, especially men peers, can engage in negative bias and treatment toward women thus affecting women's engagement and academic performance in the STEM classroom. The use of quantitative methods in these studies, with the exception of Gasiewski et al. (2012) who conducted a mixed method study, limits our understanding of how women perceive their interactions with peers. The studies presented in this section do not consider the intersection of race and gender and a mixed-methods approach may provide a more comprehensive exploration of the effects of peers on both White women and women of color.

Effects of Instruction on Women in STEM

Besides instructor/student interaction and peer interactions, the instructional tools instructors use as well as instructional methods instructors implement can affect the experiences of students in the classroom. Instructional tools, such as curriculum and syllabi, can reflect a "chilly climate" and implicitly communicate that certain populations of students do not belong in STEM. Instructional methods, such as active learning, cooperative and collaborative learning, and inclusive teaching may also have a role in contributing to outcomes such as students' sense of belonging, confidence, persistence in STEM, academic performance, critical thinking, academic engagement, and self-concept. Yet, research on these instructional methods and the racial and gendered effects on students is minimal and needs further examination.

Instructional Tools

Curriculum and syllabi may contribute to students' perceptions of the classroom environment. Murray et al. (1999) indicates that rigid exclusionary course and curriculum structure in engineering along with male students' beliefs and behaviors contribute to a "chilly climate". According to Murray et al., the "chilly climate" further persists in fields such as engineering because of the emphasis on academic competition. An inflexible classroom environment with high standards, focused on the individual rather than the group, also promotes qualities stereotypically associated with men (i.e., agentic and competitive) thus excluding women.

Instructional tools such as syllabi can send messages to women that they do not belong while maintaining a culture that values men more than women. Using a feminist discourse analysis framework, Parson (2012) analyzed eight STEM syllabi at a Midwest research institution to understand how power in the institution materialized through the language in the syllabi. Through her analyses, she found that discourses in the STEM syllabi reflected power and gender through beliefs described on the syllabi about knowledge and teaching, which reflected dominant narratives in STEM. Parson explains that although the syllabi did not explicitly refer to gender, it reflected "male-biased views of knowledge, learning and teaching that are seen in the STEM education institution" (p. 113). Knowledge was described as "static and unchanging" while descriptions of teaching centered on the narrative of the "passive student" (p. 111). She argues that these beliefs about knowledge and teaching are inherently discriminatory toward students of color and women and thus contribute to a "chilly climate".

Instructional Methods

Besides curriculum and syllabi, classroom instructional methods can also create an isolating experience for women in the STEM environment (Lester et al., 2016). Studies of the general college population have demonstrated positive effects of active learning on students' self-confidence and persistence toward graduate school (e.g., Hanson et al., 2015). Studies of cooperative and collaborative learning reveal positive impacts on students' self-concept and critical thinking (Johnson, et al., 2007; Sullivan, 2005). Yet there appears to be mixed results on the impact of active learning and cooperative/collaborative learning on students of color and women. Inclusive teaching, on the other hand, is an instructional approach specifically designed to support marginalized populations such as students of color. In two studies of students in the United Kingdom in a variety of disciplines, Hockings et al. (2008, 2010) found that inclusive teaching methods can enhance student learning and engagement, especially for marginalized populations such as women and students of color. Hockings et al. (2008) found that students valued teaching that recognized students' academic and social identities, therefore meeting their individual learning needs and interests. In a later study, Hockings (2010) found that instructors' approaches to facilitation in the classroom and questioning students influenced who participated in classroom discussions and who did not. Research on inclusive teaching is limited so understanding the effects of inclusive teaching in classroom environments has not been fully explored.

In addition to studies of the impact of instructional methods on the general student population, studies in STEM settings have explored the impacts of active learning, cooperative and collaborative learning, and inclusive teaching on students; these focus on a wide array of outcomes, including students' sense of belonging, confidence, persistence in STEM, academic performance, critical thinking, and academic engagement. Examining how instructional methods shape the STEM classroom environment for both women and students of color is important to potentially improve classroom experiences for marginalized populations.

Active Learning.

Active learning is a broad category that includes multiple interactive approaches (from clickers to small group work to frequent interaction with the instructor and peers in the classroom) which have demonstrated effectiveness in the research. Some studies have shown that active learning can also have positive effects on women and students of color including increased self-efficacy, social belonging, academic achievement, and persistence in STEM. Yet, other studies have found no effect on race and gender. The mixed findings indicate a need for further research on how active learning shapes the classroom environment for women and students of color.

Wu et al. (2018) evaluated the different learning experiences of students in three different Calculus 1 courses at a large research institution in the United States to determine if these experiences influenced students' attitudes and beliefs toward math. The 1A Calculus course (first half of a two semester course) consisted of students who were at risk of failing. The NE course, or non-engineering course, was a course specifically for students in science disciplines such as chemistry, physics, and biology while the E course was the engineering course. Amongst all the courses, the NE course incorporated more methods of active learning and group discussions. Both the 1A and E courses incorporated traditional lectures more than the NE course. Wu et al. utilized pre- and post-surveys from the national Characteristics of Successful Programs of College Calculus (CSPCC) that measured students' attitudes and beliefs during the term calculus courses were taken and compared their results to the CSPCC national dataset. They also controlled for academic characteristics (SAT/ACT math scores and high school GPA) of students and found no significant effect on the results. They found that students, compared to the national population, in the NE and E course demonstrated a decrease in confidence and enjoyment, while those in the E course also experienced a decrease in desire to continue in math. Although students in the NE course also showed a small decrease in desire to continue math, the result was not significant. Students in the 1A course, compared to the national population, also reported decreased confidence and enjoyment and a small increase in desire for more math, but the results were not significant. Because this study did not define active learning, it is not clear what types of active learning techniques were executed in the NE classroom. This study also reveals potentially mixed results related to active learning since the NE classroom, which incorporated active learning, showed significant levels of decreased confidence and enjoyment in the course. This points to a need to further understand what specific active learning techniques are more impactful on students than others.

Gasiewski et al. (2012) explored the relationship between student academic engagement and active learning in introductory science courses. The researchers created a measure of behavioral academic engagement that included the following statements: frequency of asking questions in class, discussing grades or assignments with the instructor, attending the professor's office hours, participating in class discussions, tutoring other students in the course, reviewing class material before class, attending review sessions, and studying with other students from the course. They also created a course-level variable by surveying the faculty teaching the courses and asking questions about their pedagogical style in the course, expectations of students, perceptions of students' preparation, and their faculty workload. They discovered that courses in which the instructor indicated openness to student questions and believed that part of their role was to help students succeed had more engaged students. Yet, they found no differences in academic engagement by race or gender. Although this study revealed that all students, regardless of race or gender, were more engaged in science courses when instructors used more active learning techniques, the mechanism of engagement is not fully explored. The mechanisms of engagement, which could be increased sense of belonging and less isolation, would be important to identify in a future study along with differences associated with race and gender.

While Gasiewski et al. found no differences in how active learning techniques shaped students' engagement based on race and gender, other studies show that active learning can have positive effects on students of color and women therefore improving their self-efficacy, social belonging, academic achievement, and persistence in a STEM major. Ballen et al. (2017) measured the relationship between active learning pedagogy, the achievement gap between students of color and White students and the potential increase of self-efficacy and classroom social belonging as well as performance outcomes in an introductory evolutionary biology and biodiversity course. They found that active learning pedagogy significantly increased the science self-efficacy and classroom social belonging of all students but specifically contributed to improved academic performance of students of color. Theobald et al. (2020), in a meta-analysis of 15 studies, also explored the relationship between active learning and the achievement gap of underrepresented students in STEM. After reviewing both active learning and traditional lecture classroom studies that compared the achievement of both underrepresented and overrepresented students in STEM, they found that active learning has a positive impact on examination scores and failure rates on both URMs and low-income students across all STEM disciplines.

In their qualitative study of 201 college STEM students, Rainey et al. (2019) found that White women and men of all races/ethnicities who experienced active approaches in the classroom felt professors cared more about their learning. However, women of color perceived professors in STEM as showing less care overall than other professors outside STEM. Students who reported that their professor cared about their learning also had higher rates of sense of belonging, although gender/racial differences were also consistent with demographics of underrepresented students in STEM. The study also found that women and students of color who left STEM majors had encountered mostly lecture based courses but indicated preference for active teaching practices in the classroom. Although this study highlights the potential relationship between instructional methods, perceptions of professor care, and sense of belonging in a STEM major, these relationships are less clear for women and students of color.

Although active learning can be beneficial for student performance and persistence, for some students, active learning practices such as volunteering to answer a question and being called on to answer a question in class can be anxiety inducing (Brigati et al., 2020). Aguillon et al. (2020) found that women's participation and academic performance in an active learning course was not improved. They conducted a quantitative study on large lecture-style introductory biology courses that integrated active learning practices over two semesters to determine gender differences by participation, attitudes, and performance. They observed students' participation in class by gender capturing four broad categories of student-instructor interactions. These included unprompted interactions, prompted and voluntary interactions, group random call, and group work. Students' grades and student survey responses on topics that included scientific self-efficacy, test anxiety, and study habits were also analyzed. Overall, women participated less than men in class. On the survey, women also indicated that both instructors and peers judged them more based on their gender. Men also reported higher scientific self-efficacy and higher exam grades but there were no gender differences in performance in non-exam assignments. This study shows that active learning may not be enough to support women's socioemotional outcomes in STEM classrooms. Incorporating inclusive practices along with active learning techniques may be strategies to enhance the overall experience of students. Inclusive teaching and equitable practices may have a different effect on women than men.

Cooperative and Collaborative Learning.

Cooperative learning takes a step beyond active learning in its focus on cooperation rather than competition (Sullivan, 2005). Sullivan indicates that focusing on shared values and attitudes of a community is just as important as intellectual development and skills. In a cooperative learning environment, students work in small groups, provide support and resources to each other, and celebrate each other's successes. According to Johnson and Johnson (1989), cooperation has been shown to lead to positive effects on students which include higher achievement, critical thinking, deep learning, a desire to overcome challenges, intrinsic motivation, and time on task. Within higher education settings, cooperative learning appears to foster critical thinking through student participation, teacher support, and peer to peer interaction (McKeachie et al., 1986). Additionally, meta-analyses of cooperative learning studies suggest the instructional method contributes to self-esteem, positive self-concept, positive attitudes toward learning, and civic values of caring and supporting others (Johnson & Johnson, 1989, 1996).

Collaborative learning, which is similar to cooperative learning, can also be beneficial to marginalized students, such as women and some racial/ethnic minorities, especially in the sciences. Beichner et al. (2007) evaluated the experiences of students in their SCALE UP project, in which students in large enrollment studio classes (approximately 100 students) engaged in activities in small groups of 3-4 students. Adopting the techniques from cooperative learning, the intent was to help students form small learning communities, minimize lecture, and have students present results in class. Beichner and instructors who implemented SCALE UP in their courses also were cognizant of ensuring that women and students of color were not alone in a group. In an evaluation of 16,000 students in SCALE UP classrooms, compared to traditional classrooms over a period of 5 years, they found an increase in conceptual understanding, improved attitudes, higher class attendance, and a reduction in failure rates particularly for women and African Americans. Yet, the failure rates for Native American, Asian American, and Hispanic students were no different than in a traditional classroom. Therefore, although there is some evidence through the SCALE UP studies that shows a potential relationship between cooperative/collaborative learning and race and gender, the results are mixed.

Inclusive Teaching.

As noted, there is some emerging evidence that inclusive teaching practices can influence students' experiences in college courses. According to the University of Michigan's Center for Research on Learning and Teaching Inclusive Teaching for Lecturers Departmental Feedback (n.d.), inclusive teaching

> involves deliberately cultivating a learning environment where all students are treated equitably, have equal access to learning, and feel welcome, valued, and supported in their learning. Such teaching attends to social identities and seeks to change the ways systemic inequities shape dynamics in teaching-learning spaces, affect individuals' experiences of those spaces, and influence course and curriculum design (p. 1).

Tanner (2013) explains that equitable teaching practices include ensuring fairness in classrooms by allowing opportunities for students to participate and have time to process and present ideas. Equitable methods also facilitate a personal connection to the subject and explicitly welcome students into class discussions. According to Dewsbury (2020), creating inclusive classrooms can help mediate the challenges underrepresented students encounter because of traditional exclusionary STEM methods of teaching. He contends that instructors' self-awareness, (i.e., understanding their social position and the personal histories they bring to the classroom) and empathy (i.e., listening to and understanding the needs of students) combined with pedagogy (i.e., incorporating strategies to maximize "deep learning") contribute to the development of a positive classroom climate.

As a result of competitive culture in STEM as well as study results indicating that the experiences of women and students of color differ than those of White men, inclusive teaching has emerged to make experiences more equitable. Although both inclusive teaching and active learning are often discussed in tandem, they are not the same. Inclusive teaching, broadly, values equity and fairness which considers “valuing students’ differences within mainstream curriculum, pedagogy, and assessment” (Hockings et al., 2010, p. 3) while active learning is centered on instructional methods. Inclusive teaching serves a more holistic capacity than active learning.

As demonstrated in Rainey et al.’s (2018) study, active learning paired with inclusive teaching practices (i.e., care shown by professors) can have significant impacts on marginalized populations. Other studies show the impact of inclusive strategies such as knowing students’ names, diversifying ideas about who can be a scientist, and offering instructor autonomy support. Cooper et al. (2017) explored how students felt more valued and were more invested in a biology course when they perceived the instructor knew their name. Students also felt more comfortable getting help, talking to the instructor, and enhanced their perceptions of their performance and confidence in the course. Overall, these findings indicate that a simple practice such as knowing students’ names in the classroom may improve classroom climate and contribute to a more positive, inclusive experience for students.

Students can also benefit from inclusive teaching practices that expand their perspective regarding who can be a scientist. Sheffield et al. (2021) integrated an intervention in a geoscience undergraduate course in which they introduced a scientist every week that was from a diverse background. Their interviews with 14 students found that as result of the intervention, both marginalized and non-marginalized students were able to broaden their ideas of who belongs in science and the diverse identities that can be attributed to scientists. Instructors’ interactions with students can also shape their classroom experiences. The kinds of interactions instructors have with students in their courses can also have positive impacts on students’ classroom experiences. Black and Deci (1999) investigated students' perceptions of instructor autonomy-support in an organic chemistry course, which they described as occurring when "an individual in a position of authority (e.g., an instructor) takes the other's (e.g., a student's) perspective, acknowledges the other's feelings, and provides the other with pertinent information and opportunities for choice, while minimizing the use of pressures and demands" (p. 742). Black and Deci found that when students perceived their instructor to have high autonomy-support, students more autonomously self-regulated their study habits in chemistry. Students' perceived competence as well as their interest/enjoyment in the subject increased, while their anxiety decreased. Hall and Webb (2014) conducted a similar study in which five graduate instructors taught nine sections of a physics course separately. They found a positive relationship between students' perceptions of instructor autonomy-support and students' interest/enjoyment in physics, decreased anxiety related to physics, and increased autonomous reasons for studying physics.

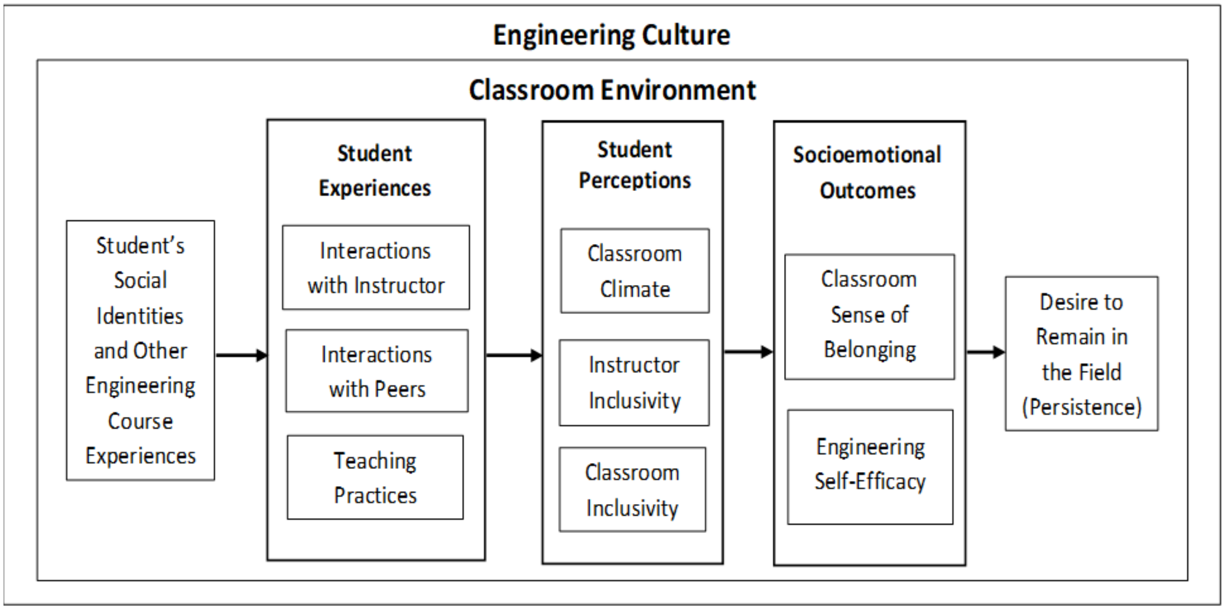
While some research suggests that students can benefit from inclusive teaching practices in STEM classrooms, more needs to be done to understand how the race and gender of students impacts their experiences in the classroom. Academic performance and academic engagement appear to be significantly associated with students' race and gender. Yet, the effects of inclusive teaching on students of color and women such as self-efficacy, sense of belonging, and desire to remain in the field demonstrate mixed results. To date many studies of inclusive teaching have been conducted across disciplines and results have not been disaggregated by discipline. Others are specific to biology, physics, math, and chemistry. Particularly in engineering, there is limited understanding of the effects of inclusive teaching on women and people of color. Identifying the role of instruction as well as interactions between men and women peers may provide greater insight into identifying the main causes of a "chilly climate" in a field such as engineering and may also point to a broader cultural problem within engineering.

Conceptual Framework

My review of the literature provided me with a set of assumptions that I synthesized into the conceptual framework that guided data collection and analysis for this study of women's experiences in engineering courses (Figure 2.1). Reviewing the literature on engineering culture indicated that it had a significant role in engineering environments, especially the classroom so the framework assumed that engineering culture shapes the interactions that happen in engineering classrooms. Much of this literature portrays engineering culture in a negative light and based on these readings I identified engineering culture as being toxic and exuding patriarchy, valuing meritocracy and objectivity, and projecting beliefs of feeling superior to others, particularly students. Embedded in this culture, engineering students enter courses with social identities that are not only not the norm, but that may be viewed through a deficit lens. The framework further assumed that teaching practices can contribute to gendered and racialized classroom experiences for women. Specifically, it posited that teaching practices would affect all students' perceptions of classroom climate, classroom inclusivity, and instructor inclusivity, and that these perceptions could vary by gender and race/ethnicity. In addition, it also assumed that course peers would influence students' perceptions of the classroom environment. Yet, I recognize that for students who are the numerical majority in engineering classrooms and who share the values of the dominant engineering culture, educational experiences in engineering programs and courses may not feel toxic or exclusionary.

Figure 2.1

Conceptual Framework for the Study



The framework next assumed that students' perceptions of classroom climate, classroom inclusivity and instructor inclusivity would affect students' classroom sense of belonging and their engineering self-efficacy. Ultimately, students' sense of engineering self-efficacy and classroom sense of belonging were assumed to influence their intentions to remain in the field (i.e., their persistence).

In this study, my primary focus is instructor's teaching practices and their impact on women students but as I conducted the study, I planned to remain sensitive to peer effects to develop a more holistic understanding of how classroom experiences affect the socioemotional outcomes of women students. After I collected and analyzed my data, I revisited my conceptual framework to revise it based on my findings. Chapters 4 through 7 detail these findings and I discuss their implications for theory, research, and practice in Chapter 8.

Conclusion

Overall, studies of STEM classrooms show that faculty/instructors, peers, and instruction can contribute to "chilly climates'' in classrooms, but there are few studies that specifically investigate how teaching and peer interactions in engineering courses affect students, and undergraduates, who identify as women and women of color. It is likely that the historical lack of representation of women in engineering, and especially women of color, contributes to the ways women in engineering are perceived and treated. Faculty and peers who interact with women students in the engineering classroom may contribute to a classroom climate that marginalizes women and potentially impacts their current and future participation in engineering. How teaching practices potentially contribute to disrupt this marginalization is thus an important question.

Even within engineering, however, disciplinary cultures can differ. In a longitudinal mixed-method study, Murzi et al. (2016) analyzed disciplinary engineering culture at six institutions specifically comparing electrical engineering and industrial engineering because of their differences with diversity and orientations toward individualism versus group work. This reveals that even among engineering disciplines there can be variability of values that must be considered in research.

Focusing on the nature of the classroom experience in required courses in chemical engineering majors, the research questions for this dissertation study are:

1. What is the nature of the learning environment the instructor plans to establish and enacts during the course?
2. How do students perceive the instruction provided?
3. a. How do students perceive the learning environment?

b. How do perceptions of instruction influence their perceptions of the learning environment?

4. How do students' perceptions of the learning environment relate to students' engineering self-efficacy and course sense of belonging?
5. a. How does engineering self-efficacy and course sense of belonging relate to desire to remain in the field?

   b. Do perceptions of the learning environment, engineering self-efficacy, course sense of belonging, and desire to remain in the field vary by gender?

   c. Do these vary for women based on race/ethnicity?

Although I use the term "course" in my research questions, I use the term "classroom" throughout my discussion of my study because I am using the definition of a classroom that indicates it is any place where one's learning occurs. Although this study was not situated in a physical classroom, students were in an online space where learning was occurring. Thus, the term classroom is used to describe my variables in this mixed-method study.

Understanding how instruction shapes learning conditions for women and women of color at the postsecondary level is important because structural diversity has not made enough significant improvement in the gender disparity in engineering. Both Blickenstaff (2005) and Cheryan et al. (2017) argue that simple solutions such as increasing women science role models may not have a large impact on improving women's STEM degree attainment particularly if women are not being fully accepted into the STEM fields. Therefore, it is important to identify solutions to ensure women in STEM, especially in engineering, are provided with an equitable learning experience so that they too have the opportunity like men to make valuable and important scientific contributions.

Chapter 3 Methodology and Methods

Overview

The purpose of this research is to understand the effects of instruction on women in engineering classrooms. In this chapter I describe the methodology that guided my study and the methods used to answer my research questions. I use the term “classroom” instead of the broader term “course” I use in my research questions throughout my discussions in this chapter because I am using a definition that identifies a “classroom” as a place where learning occurs. The online space was a place where learning was occurring, so I refer to this as a classroom in my discussion in this chapter.

In brief, feminism informed my methodology as I designed and engaged in this mixed-methods study, in which I combined qualitative and quantitative strands to understand women’s experiences in the classroom, and how sexism and racism contributed to those experiences. My data was collected at different time points during two courses, analyzed separately, and then merged to compare and contrast the findings (Creswell & Clark, 2017).

I begin by discussing my methodology and positionality and how these informed my study. Then, I discuss my research methods, beginning with a description of the research setting – two chemical engineering lecture style courses at a selective research-intensive university – and the study participants. A detailed explanation of the data collection and analysis procedures follows. I conclude by discussing how the qualitative and quantitative aspects of the study were integrated and how I used the convergence of both to further understand the impact of instruction on women in engineering classrooms.

Methodology

I bring a social constructivist view of knowledge to this study, in which I believe that knowledge has "been developed so as to reflect the interests of the most powerful groups in society" and over time become unconsciously adopted and embedded into societal values (Phillips & Burbules, 2000). My epistemology is grounded in constructivism, which asserts that knowledge is co-created between the researcher and the participants (Jones et al., 2014). This epistemology influenced how I interacted with the instructors and the students in this study to understand how they made meaning of what occurred in their classrooms. My social constructivist view influences my use of a feminist theoretical framework that recognizes the power of engineering culture to create racist and sexist environments that exclude groups not part of the dominant engineering culture. I am particularly interested in how White women and women of color are influenced by these educational environments. As a feminist researcher, I intend for my research to engage in "consciousness raising" while examining gender critically and utilizing women's experiences as a scientific resource (MacKinnon, 1982). Finally, aligned with my feminist research approach, I utilized self-reflexivity as I engaged in multiple methods that required me to observe and to listen. I also want to make an impact on the community I am studying so I intend to utilize my research as a form of advocacy rather than exploitation of the voices heard (Jones et al., 2014). I also utilize the concept of intersectionality to further understand how multiple systems of oppression (racism and sexism) affect women of color in the engineering classroom recognizing the racial variation within gender (Nash, 2008). Nash explains that intersectionality is a useful way to challenge feminist exclusion of women of color. In the section that follows, I explain in greater detail how these feminist and intersectional perspectives guided my study.

Feminism influences the way that I understand the sexist and racist power structures that exist in the engineering classroom. Harding (1991) argues the scientific methods that are used in science, with the goal of eliminating social influences and values, are supporting the values that are part of the predominant white, Eurocentric, and masculine culture of science. Feminist Standpoint Theory, Black Feminist Standpoint Theory and Feminist critiques of pedagogy can expose the mechanisms of dominance that operate in an environment or situation. In an environment such as an engineering classroom, which is heavily influenced by science culture's positivist paradigm, power structures can materialize through dynamics between instructors, peers, and students.

Historically, science culture has centered the voices of White men while actively excluding women in the process (Roychoudhury et al., 1995). Integrating a feminist standpoint is to oppose the positivistic approach that attempts to define women's low levels of participation in scientific and technical fields by placing blame on the woman (i.e., lack of interest, lack of spatial skills, etc.). A feminist standpoint argues that women are not the problem; rather structures in place in social institutions prevent women from being considered equal to men. Therefore, understanding women's perspectives and experiences from their position in the engineering classroom (the social hierarchy) is important to understand if and how they differ from men, which may reflect engineering socio-cultural norms, and if these perspectives influence their decisions to remain in the field and their academic achievement. Harding (2005) explains that using a feminist standpoint theory allows for "oppressed, dominated, and exploited social positions to identify otherwise hidden realities of social life" (p. 351). Taking a feminist standpoint requires that I center the experiences of White women and women of color to understand if and how oppression operates in engineering classrooms.

The historical institutionalized practices of science contribute to the idea that science is universal and that a person's social identity does not influence scientific practice. According to Ladson-Billings (2000), a critical race scholar, these dominant paradigms within science can limit the voices of those with differing cultures and identities. Black feminist standpoint theory provides further insight into interlocking issues of dominance that can emerge in social structures such as an engineering classroom. Collins (1986) describes economic, racial, and gender oppression as interlocking, thus indicating that by only focusing on one, you neglect oppression in the other areas. These interlocking forms of domination create a dualistic pattern that place categories at odds with one another (e.g., White/Black, men/women, reason/emotion) in which the categories "gain meaning only in relation to their difference from their oppositional counterparts" (Collins, 1986, p. 520). In this study, I thus take an intersectional approach in which I consider how race and gender intersect to shape students' perceptions of their experiences in engineering courses.

Examining students' perceptions of instruction is central to my study as instruction can reproduce racism and sexism. I considered this notion as I learned about the professor's pedagogical beliefs, observed their pedagogical practices, and studied students' responses to their manifestations. According to hooks (1994), she explains that instructors in traditional classrooms often treat students as "passive consumers" and follow a model in which students are taught material and are expected to memorize and repeat it back. She further argues that this type of teaching reinforces domination and prevents liberatory education in which power structures are dissolved and a community of instructors and students is formed, thus enhancing engagement and learning in the classroom. By focusing on how students perceive instruction I sought to understand how teaching creates educational environments that can enhance or diminish the learning experiences of women students in the engineering classroom.

Studying the experiences of women in an engineering classroom can not only demonstrate how oppression manifests but also reveals ways that it can be altered. By centering my study on women in engineering classrooms, I am acknowledging women as "subjects of knowledge and history" providing them with historical agency rather than exploitation (Harding, 2005, p. 358). Because engineering historically has engaged in both gendered and racialized exclusionary practices, feminist standpoint theory is useful to understand how dominance in the engineering classroom operates. In addition to pedagogical practices, interactions between students and peers and students and their instructors exposes the subjugation and dominant behaviors of those that conform to engineering culture in the classroom. My data collection strategies were therefore designed to provide an understanding of students' experiences in the classroom and how both race and gender contributed to those experiences revealing forms of subjugation for women.

In addition to the feminist framing of my study, I integrated aspects of feminist methodologies, which include centering women's voices and recognizing intersecting forms of oppression and structures of power which engage in domination of the oppressed. As I analyzed the data, I wanted to make sure that I was accurately sharing participants' stories and their feelings related to oppression. I also took steps in my analysis to make sure I centered women of color's experiences, discussing their intersecting experiences of sexism and racism while considering the power dynamics evident in engineering between the instructors and students, which also influenced the data analysis.

Positionality

Price and Kerschbaum (2016) describe researchers, with their time, gaze, and emotion, as characters that are part of a scene. As I engaged in this research, I recognized my role in the "scene" and the importance of self-reflexivity – my awareness of my own role and positionality in the research. My identities as a cisgender, non-STEM, Latina have shaped the construction of my research. My personal experiences working in computing and engineering as an administrator and witnessing the subjugation of women motivates my research. I have also witnessed systems of exclusion in my own experience as a woman and my interactions with women students, instructors, and administrators in STEM. As a feminist, I know that the structures of power that oppress and exclude White women and women of color can operate in blatant ways in STEM environments. Therefore, I sought to validate women's experiences in my interactions with participants in my study, but also challenged "women's taken-for-granted" experiences in my analysis (Kitzinger & Wilkinson, 1997). This entails providing a feminist critique of women's experiences that are "constructed under (hetero) patriarchy" (Kitzinger & Wilkinson, 1997, p. 573). I also recognized the diversity and contradiction of women's experiences and how this can be shaped by race.

As a researcher, I am aware of my position of privilege and was conscious of any power dynamics that could potentially contribute to the interactions I had with students. I engaged in vulnerable listening, centering the voices of participants to mitigate any power dynamics. I also practiced what McClelland (2017) refers to as an "ethics of caring" for the stories and experiences participants shared. This ethic of care extended to all my study participants and centered the voices of women so that they could be empowered to speak and exercise their agency (Page, 2017).

I focused on creating an open environment by building rapport with the instructors and students as I conducted the interviews and had informal interactions with them. I listened carefully to participants asking questions that invited them to share their experiences honestly with my choice of words and my body language. I employed McClelland’s (2017) “vulnerable listening” placing focus on the “affective and embodied aspects of listening, as well as potential ethical considerations” (p. 1). The relationships I created with my participants were important to me and I considered the three aspects of McClelland’s vulnerable listening which include: emotional dangers associated with listening, the unacknowledged role of the listener’s body, and the role of extreme emotions such as outrage.

I recognized that as a vulnerable listener I had to consider the impact of the research on myself and the role of my emotions. After many interviews especially with women who shared experiences of denigration through sexist interactions, I experienced what McClelland (2017) refers to as “outrage” of both sadness and anger. McClelland discusses how vulnerable listening can lead to the researcher feeling “outraged” while the participant does not. I reflected on these experiences after the interviews with my professional colleagues including my advisor to check in on my emotions and as McClelland describes, to understand how my emotions were shaping the research.

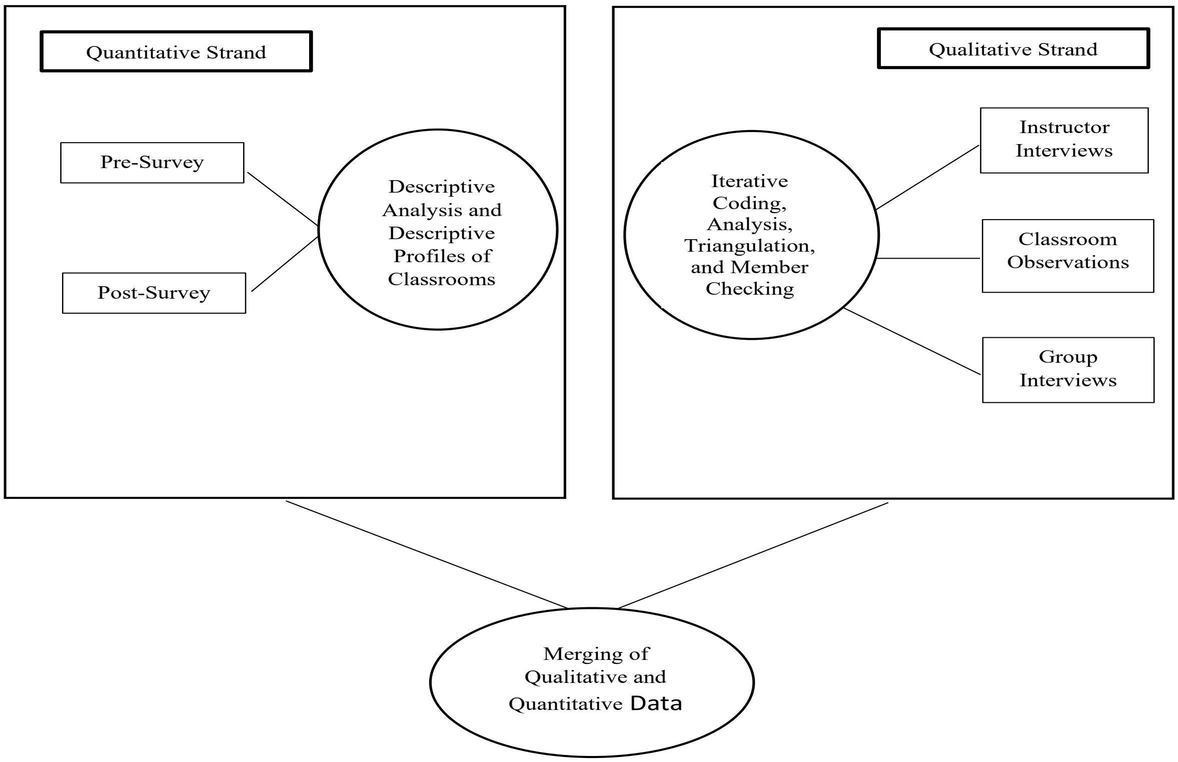
Methods

My feminist lens and social constructivist epistemology influence my desire to engage in my research that examines gender critically. This feminist lens is particularly beneficial to not only provide a voice but to advocate for marginalized participants. Grzanka (2016) explains that both quantitative and qualitative research can create an “optics of knowing” which has the power to cause “subjugation and unjust reductionism” (p. 134). The goal of this research is not to replicate harmful practices that merely quantify results without telling a deeper and more complex story. For me, it was important to use a person-centered approach when analyzing my qualitative and quantitative data. This person-centered approach, as described by Grzanka, allowed me to recognize differences in response patterns not only between groups but within groups in my study. I chose to utilize mixed methods for two main reasons: (1) to gain a better grasp of my research problem by examining numeric trends in my quantitative data and expanding on particular elements through the qualitative data and (2) to comprehensively capture the needs of those who are marginalized or underrepresented (Hanson et al., 2005). This mixed-method design uses a sequential transformative design in which feminism serves as an epistemological anchor to the conceptual framework. Although I collected both quantitative and qualitative data, priority is placed on the qualitative data (Hanson et al., 2005) and the quantitative data thus supplements my qualitative findings.

According to Creswell and Clark (2017), mixed methods "harness strengths that offset the weaknesses of both quantitative and qualitative research" (p. 12). My research questions, which are focused on understanding how students experience the classroom environment, as well as the instructor's role in creating that environment, merit a mixed method approach. Using qualitative or quantitative methods alone would have limited my understanding of students' perceptions of how instruction shaped the classroom environment. Combining quantitative and qualitative methods helped me give voice to marginalized populations with varying perspectives regarding experiences in engineering classrooms. Figure 3.1 shows a procedural diagram that demonstrates how mixed methods combine in the study.

Figure 3.1

Procedural Diagram of Mixed Methods



Research Setting

The location of the study was at a large selective research university. According to the AAU (2021), this type of institution in 2019 awarded 49% of research doctoral degrees and 20% of undergraduate degrees in STEM and social sciences. I chose this context because it is a large research university with generally high enrollment in their courses. Most undergraduate engineering programs enroll large numbers of undergraduates, but they vary in the percentages of women and students of color enrolled. I chose to study Chemical Engineering courses. According to the university's data, this engineering subdiscipline has about 50% women enrolled in the major as well as 18% students of color which is the highest of any other engineering discipline. According to NCSES (2022) data, women in 2018 were awarded 32% of chemical engineering degrees, the highest of all other engineering subdisciplines.

I selected two high-enrollment, undergraduate Chemical Engineering courses to study; one is typically required the second year of undergraduate study (ChE 101)[2] while the other is typically required in the third or fourth year (ChE 201)[3]. Enrollment for ChE 101 was 101 students, while ChE 201 had 77 students. The second-year course is a gateway course which is considered a rigorous entry point to the discipline and can influence a student's decision regarding continuation in an engineering major. In designing the study, I thus chose to study a gateway course to determine if this would influence one of my dependent variables, desire to remain in the field. Yet, it appears in the data that it did not make much of a difference because students in both courses indicated a strong desire to persist in the major.

Both courses were offered online in a synchronous format in the year I conducted the study. These courses had not previously been offered in an online format but were moved to an online format during the COVID-19 pandemic. Both courses utilized Zoom and a course management system, but the course designs differed. The instructor for ChE 101 did not utilize a midterm or final exam but instead relied on weekly periodic quizzes to assess student learning. These weekly quizzes ranged from 2-12 per week depending on the amount or problems in each quiz. Because the course was based on acquiring points, students could decide how many quizzes they wanted to complete to get the grade they desired. Almost all the quizzes offered unlimited tries and were open note/open book. The instructor in ChE 201 gave three exams (two midterms and one final cumulative exam) and students worked in small groups weekly after each class session. Students in ChE 201 had to turn in their group solutions to the in-class problems after their designated group time after class. A grader that was assigned to the class graded the in-class problems. The students also had to complete weekly homework assignments which were also

[2] Pseudonym used to mask course
[3] Pseudonym used to mask course

graded by the assigned course grader. All assignments and exams were factored into the final course grade. Student attendance for ChE 101 was approximately 50-60% for each class session while attendance for ChE 201 was approximately 90% throughout the term. Both classes were recorded for students who did not attend class due to illness or other conflicts. Table 3.1 provides selected characteristics of each course in the study.

Table 3.1

Characteristics of Courses in Study

	ChE 101	**ChE 201**
Class Level	2nd year	3rd year
Instructor's Pseudonym	Roger	Amar
Number of Students in Course	101	77
Course Format	Lecture/Discussion	Lecture/Group Work after Class
Instructional Approach	Some Active Learning	Some Active Learning
Formative Assessments During Class to Determine Student Comprehension	Zoom Polls	Zoom Polls
Summative Assessments of Individual Student Learning	Weekly Quizzes (2-12 per week)	2 Midterms and 1 Cumulative Final Exam
Feedback on Course Design	Midterm Evaluation	Midterm Evaluation
Days of Course	MWF	TTh

Participants

I received IRB approval (HUM00163863) to conduct this study in engineering classrooms and through this process developed procedures to protect the participants in the study. Recruitment and data collection procedures were piloted during a 7-week Industrial and Operations Engineering course to determine what needed to be adapted and changed for the full study.

I selected two instructors based on information from the course coordinators and engineering advisors in the chemical engineering department, who shared information about teaching approaches and student feedback on instruction. The professor of ChE 101 was a tenured professor who had extensive teaching experience, and who reportedly purposely included attention to issues of diversity, equity, and inclusion (pseudonym: Roger). The professor of ChE 201 was a tenure-track assistant professor with significantly less teaching experience but who was similarly reported to value inclusivity (pseudonym: Amar). I reached out to both instructors via email explaining my study broadly but did not initially share my focus was on women. I also outlined what they would need to agree to if they participated in the study. The language of the recruitment email is located in Appendix A. Once the instructors agreed to meet, I set up virtual meetings and described my study more in depth disclosing to them that my focus was on understanding women's experiences in the classroom. Both instructors agreed to participate in the study and received a total of $200 for their participation in two interviews, one at the beginning of the course and another at the end of the course. The instructors accommodated my request to award students extra credit points for completing both pre- and post- surveys for my study. I checked in regularly with the instructors throughout the semester connecting with them when I needed to distribute the surveys or recruit participants for the group interviews.

Although I disclosed the purpose of my study to the instructors of the courses because I did not feel that it would affect their teaching, I did not inform the student participants of my study's focus. Rather, I shared with the students that I was trying to understand students' experiences with instruction generally. I felt that if I shared the study was focused on women's experiences, some students may have felt restricted in what they felt they could share with me or may have not wanted to participate. The initial communication sent to recruit participants in the study is located in Appendix B. At the conclusion of the course, I sent an email to all participants debriefing them on the main purpose of the study. The debriefing message that was sent is located in Appendix C.

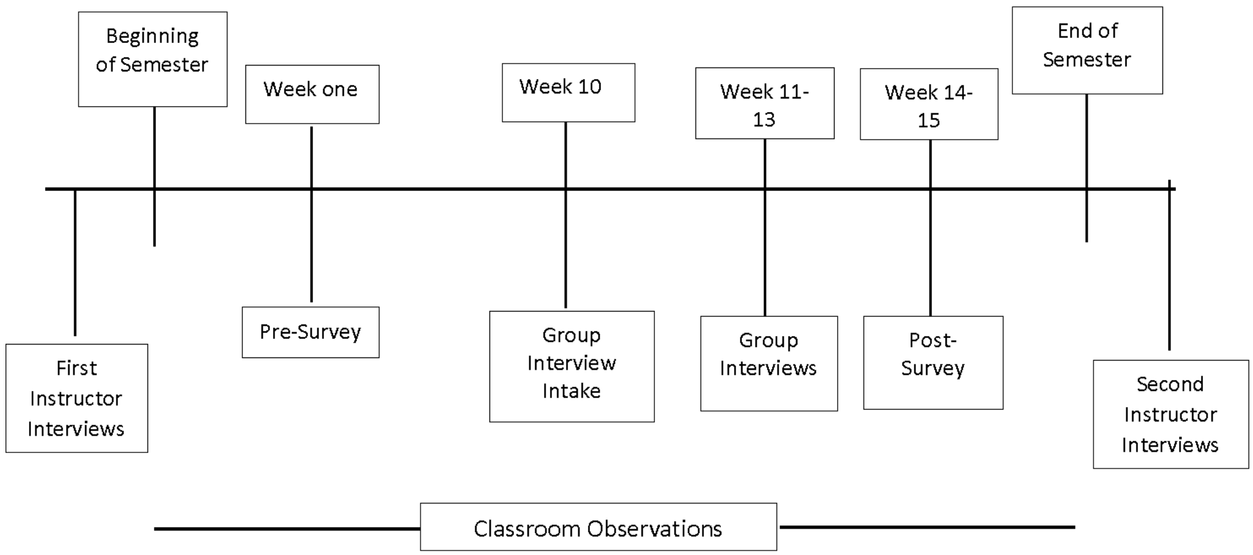
Students were recruited for the study on the second day of classes. During that class period, each instructor allowed me to describe my study and the potential ways to participate (via either survey or group interviews, or both). Incentives included a drawing for five $100 cash cards per course and instructors agreed to award students extra credit points if they participated in both the pre- and post-survey. For the group interviews, students were offered a $30 cash card for their participation. With the instructors' permission, I utilized the Zoom chat function to invite students to fill out the electronic surveys and I also emailed them using the course management system. Four weeks before the conclusion of the courses, I recruited students for group interviews by sending a sign-up form through the Zoom chat function and via the course management email function. I coordinated the interviews using group texts to set up times for the participants to be interviewed via Zoom.

Data Collection

Data for this study included classroom observations, interviews with the instructors, and group interviews, all conducted via Zoom, and electronic pre- and post-student surveys. Figure 3.2 provides a timeline of the data collection process.

Figure 3.2

Timeline of Data Collection



The integration of quantitative and qualitative data, or mixed methods, created complementarity in which each method assisted in understanding the results of the other method (Hanson et al., 2005). Although my study utilized quantitative analysis, this strand did not aim for generalizability to engineering students in general but rather focused on understanding how engineering students in these courses perceived their instruction and how these perceptions affected their assessments of classroom climate, their sense of belonging in the classroom, and their engineering self-efficacy.

Instructor Interviews.

The instructors in each course were interviewed via Zoom at the beginning and end of the semester. I used semi-structured, phenomenologically based interviewing that focuses on the experiences of individuals and how they formulate meaning from those experiences (Seidman, 2012). The primary goal of the initial interview was to understand the instructor's teaching practices, beliefs about inclusivity, their interactions with students, and their beliefs about engineering. These served as sensitizing concepts for the qualitative data collection and analysis.

In addition, the first interview consisted of open-ended questions centered on instructors' goals for the course, their beliefs about what makes an engineering student successful, how they sought to create a certain classroom environment, and how they addressed any instances of student disruption and difficult group dynamics in the past. In addition, I sought to develop rapport through attentive listening in which I expressed both interest and understanding with what the instructors shared (Kvale, 2007).

The second interview served as an opportunity for reflection on the instructor's experience teaching the course. I asked instructors for their assessment of the classroom environment, difficult moments that occurred in the course and how they addressed them, observations about students working in groups and any tensions based on differences, and thoughts about how they might alter the course in the future if they choose to do so. The questions in the initial and end-of-course instructor interviews are in Appendix D.

Classroom Observations.

Given my research interest in instructors' teaching practices, I observed the class sessions for each course synchronously as a participant on the Zoom platform, except when there were exams in Amar's course. I adapted the Teaching Dimensions Observation Protocol (TDOP) (Hora & Ferrare, 2014) that aims to capture not only typical teaching practices such as lecturing and small group work, but also subtle pedagogical strategies such as hand motions and humor, interactions with students such as call and response, cognitive engagement such as problem solving, and the use of instructional technology. During my observations I also captured occurrences that I perceived to be related to inclusive teaching – which are not part of the TDOP observation protocol but which might be utilized by instructors (e.g., using students' names, telling students that they had the ability to succeed, explaining that the work was challenging and that it was ok to struggle, allowing time for students to process material in class, and requesting formative feedback from the students). For guidance, I consulted the University of Michigan's Center for Research on Learning and Teaching Inclusive Teaching for Lecturers Departmental Feedback form (CRLT, n.d.). This includes practices such as explaining learning objectives, explicitly communicating expectations, emphasizing how struggle and challenge are important parts of the learning process, helping students connect prior knowledge to new learning, and using strategies for including a range of voices.

My adapted version of the TDOP did not use timed intervals for data collection because I did not seek to produce counts of each teaching practice. Rather, I used the protocol to take brief notes on the use of different kinds of teaching practices that I observed during a class session. These notes were intended to aid description of the classroom contexts and to triangulate data on the types and overall frequency of particular teaching practices that students reported. After each week of taking notes on the teaching practices of the instructor and the classroom context, I developed summaries of what occurred. I then coded the summaries using similar codes I created for the instructor and group interviews. This aided me in identifying particular instances in class that students in my group interviews mentioned. I also kept track of the number of students that attended class, the number of cameras, and the gender composition of those that used the cameras. I used this data to develop context for the course. I did not use the TDOP to evaluate instruction. Instead, the adapted version of the TDOP served as a tool to aid systematic observations of instructors' teaching practices. The observation protocol can be found in Appendix E. A sample of my notes from the class session observation protocol along with fieldnotes is located in Appendix F.

In addition, I utilized some of the practices that ethnographers employ when conducting observations. For example, I took notes of my initial impressions of the classroom context, capturing the nature of the settings through “jottings” (Emerson et al., 2011). Finally, in ethnographic style, I created weekly summaries of class sessions utilizing my notes and jottings to help me process the class sessions. Examples of two class session summaries based on my fieldnotes and the summarized data from the TDOP data are located in Appendix G.

. In my observations, I noted that both instructors kept their cameras on during every class. In Roger’s course about 30 students typically kept their cameras on during class while in Amar’s class fewer than three students typically were visible on camera. This was not a concern because the focus of the observation was the instructor and his teaching practices. Rather than trying to interpret student behaviors in the online classroom, I relied on students’ reports of their perceptions of their instructor’s teaching practices. I was, however, able to capture interactions that happened between students and the instructor via the Zoom chat function and when students unmuted and responded in class or posed a question, I coded such behaviors during my analysis.

Each instructor integrated active learning, to different degrees, into his lecture. Roger incorporated some think-pair-shares in which he presented a question or topic and had students discuss in breakout rooms. He often engaged the students by posing questions and having them answer either through the chat or using their microphone. Amar often used Zoom polls, which functioned like clickers, allowing students to think about a conceptual question and then respond through the poll. He presented the results of the polls to the students and used these polls to determine which concepts he needed to spend more time reviewing. The structure of Amar’s course was unique in that it included a portion of time dedicated to in-class group work. Amar lectured in the first half of class, then students were sent to breakout rooms with their self-selected group to work on in-class problems. He along with the Teaching Assistants in the course stayed during this portion of class to help answer any questions the students had about the problems.

Amar’s course met twice a week for 1 hour and 15 minutes of lecture. Students were sent into their break-out room groups after this time and I did not attend this portion of class. Roger’s course met three times a week for 50 minutes of lecture. Students had discussion sessions with a graduate instructor at different times during the week that I did not attend.

Group Interviews.

In my study, group interviews were used to understand how students perceived the classroom environment (specifically teaching practices, instructor inclusivity, classroom inclusivity, and classroom climate) and the effect of those perceptions on their desire to remain in the field (chemical engineering), their classroom sense of belonging, and their engineering self-efficacy. I chose group interviews because I wanted to create a “safe” space where woman could speak about their experiences and reflect on each other’s thoughts about their experiences. I felt that group interviews would elicit more responses than individual interviews because if one woman shared an experience, it would motivate other women to share as well. According to Bohnsack (2004), group membership provides a shared experience in which collective orientations can emerge using reflexive principles. Bohnsack suggests focusing group questions on the “center of experience” while employing strategies such as sequencing questions, allowing students to moderate themselves as they answer the questions, asking for detailed narratives, and utilizing follow-up questions. Therefore, I developed group interview questions that asked about specific experiences in engineering rather than eliciting broad engineering experiences to encourage openness from the participants. I also disclosed my connections to engineering research as I recruited participants and during my interactions with students in the interviews.

I chose to take an intersectional approach in my study when creating the groups because I felt it was important to consider intersections of race and gender to determine how they influenced students' experiences in the classroom. In line with an intersectional understanding of social identity, I conducted group interviews categorized by race and gender to understand how different student populations responded to certain teaching practices and to potentially increase students' comfort to discuss their classroom experiences.

I created my group interview script with a goal of eliciting responses that would engage the entire group in self-reflection. This is one of the reasons I placed my question about social identity at the end of the interview. My questions built upon one another to make the students think about their classroom environment, the role of the instructor and students in contributing to that environment, and the effects of their social identity on their experiences in the classroom. I allowed students to moderate themselves by trying my best to say very little allowing them to converse with each other about their thoughts and to have conversations that led them to agree on similar shared experiences. I also followed up on certain questions to probe further into some of the stories or experiences they were sharing. I often summarized their responses to questions to make sure I was accurately understanding what they were telling me. The group interview questions are in Appendix H.

Student Survey.

The pre-survey collected demographic data (sex/gender, race/ethnicity, international student status along with country of origin, parent's highest level of schooling) and measured two of the dependent variables: desire to remain in chemical engineering and engineering self-efficacy. I measured these two variables because literature indicates that these variables have the potential to change over time. Desire to remain in ChE was originally included as a dependent variable but the measure lacked variability, so it was not included in the analyses. The post-survey collected demographic data including sex/gender, race/ethnicity, international student status along with country of origin, parent's highest level of schooling, major, course, and class year. It also included measures of student-centered teaching, instructor inclusivity, classroom inclusivity, and classroom climate, which all served as independent variables. The survey also included all three dependent variables: engineering self-efficacy, classroom sense of belonging, and desire to remain in ChE (dependent variables). The post-survey was designed to gather data from the broader population of students who chose to not participate in a group interview. In building my survey, I used existing measures and did not set out to specifically measure certain types of instruction. Rather, I assumed that the instructors were not engaged in any type of significant teaching practices but made sure to include a wide range of survey items related to instruction so I would capture a variety of teaching practices that might either positively or negatively influence students' perceptions of instruction.

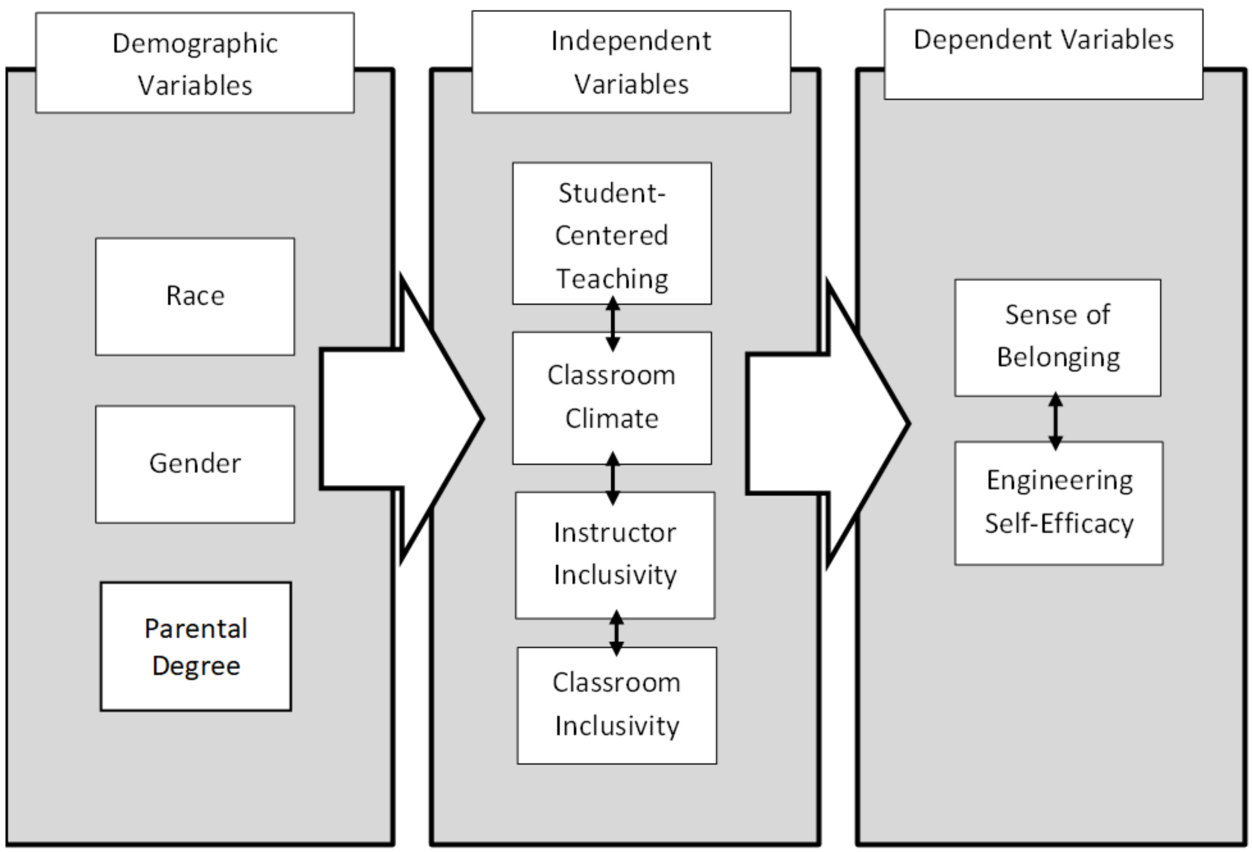
Tested and validated scales were adapted for the dependent and independent variables except for the desire to remain in ChE which was a categorical variable. Before administering the survey in the study, the survey was piloted with 37 students enrolled in an industrial engineering course. A preliminary analysis of pilot data for the dependent and independent variable scales revealed reliabilities that had a Cronbach's alpha of .75-.94 (see Appendix I for factor loadings). Although some items in the classroom inclusivity and classroom climate scales had low factor loadings, I did not eliminate any questions after the pilot study because of the small sample size. The pre- and post-survey are in Appendix J and Appendix K.

Dependent and Independent Variables.

The dependent and independent variables in the study are described in Figure 3.3, which depicts the logic of the framework that guided the statistical analysis of survey data. This is further explained in the following sections.

Figure 3.3

Statistical Framework Model



Demographic Variables.

Sex/gender, race/ethnicity, and parental degree were the demographic variables used in the study in both the pre- and post- survey. All the variables were categorical. To measure sex/gender, students were asked "What is your gender?" where 1 = male, 2 = female, and 3 =

non-binary. Because there were only two non-binary students, they were removed from the sample. I am cognizant that the response categories provided for gender are in fact categories used for sex. This was an oversight and will be corrected in future studies. To measure race, the question asked was, "What is your race/ethnicity?". The categories included African American/Black (non-Hispanic), American Indian/Native American, Asian American/Pacific Islander, European American/White (non-Hispanic), Hispanic American/Latino/a, and Other. The final categories included Asian, White, and Marginalized in STEM which combined Black, Hispanic, Multiracial, and Native American students because of their low numbers compared to the other categories. One student who chose to not share their race was excluded as well as were international students. International students were excluded because it was determined that they may have different beliefs or experiences about race/gender in STEM based on their experiences in their country of origin. To measure first-generation status, the following question about parental degree was asked "What is the highest level of formal schooling completed by either of your parent(s)/guardian(s)?". Responses included "did not finish high school", "high school graduate/GED, "attended college but did not receive a degree", "vocational/technical certificate or diploma", "Associate or other 2-year degree", "Bachelor's or other 4-year degree", "Master's degree (MA, M.S., M.B.A, etc.)", "Doctoral degree (Ph.D., J.D., M.D., etc.)", and "unknown/not applicable". Categories within this variable were also combined with the final categories including: "some high school/high school", "some college", "college degree", "Master's degree", and "Doctoral degree".

Independent Variables.

The survey also included validated survey measures to assess classroom climate, student-centered teaching, instructor inclusivity, and classroom inclusivity. These measures were important to include to understand whether a relationship existed with sense of belonging and engineering self-efficacy and to determine potential effects on women. Table 3.2 shows the items in all the measures used in the study.

Table 3.2

Factor Analysis of Variables

Instrument Item	1	2	3	4	5	6	7	8
Student-Centered Teaching								
Set clear expectations for performance	0.79							
Convey the same material in multiple ways (in writing, diagrams, orally, etc.	0.77							
Explain new concepts by linking them to what students already know	0.84							
Use examples, cases, or metaphors to explain concepts	0.82							
Answer questions or gone over material until students "got it"	0.82							
Provide encouragement to students through actions, words, or norms in class	0.86							
Demonstrate a willingness to work with students	0.79							
Provide examples that represented different backgrounds, identities, and culture	0.75							
Instructor Inclusivity								
I felt comfortable asking questions in class		0.77						
I felt that my instructor believed I was capable of succeeding in this course		0.86						
I felt included during classroom activities		0.81						
In general, my interactions with the instructor were positive		0.88						
The instructor treated everyone in class fairly		0.88						
The instructor showed respect for students		0.83						
The instructor fostered a classroom environment where students could express their opinions or perspectives		0.85						
Classroom Inclusivity: Learning-Centered Environment								
The instructor welcomed feedback from students and used it to improve the course			0.76					

The instructor supported students working through conflict or tensions	0.71			
The instructor developed a supportive environment for learning of all students	0.92			
The instructor developed an encouraging environment for learning	0.92			
The instructor cares about my learning	0.88			
Classroom Inclusivity: Instructor Bias				
The instructor used stereotypes based on race in the class		0.99		
The instructor used gender stereotypes in class		0.99		
The instructor used stereotypes based on socioeconomic class in the course		0.97		
Classroom Sense of Belonging				
I know I can turn to my peers in this course for academic assistance.			0.84	
My classmates and I share relevant class-related information with each other.			0.81	
I would be comfortable talking to my classmates about any challenges I was experiencing in this course.			0.78	
I have friends in this class who I feel I could count on if needed.			0.76	
My classmates and I are supportive of one another.			0.88	
I feel like other students in this course respect me.			0.81	
I feel like I am a valued member of this classroom community.			0.84	
When studying for this course, my classmates and I often tried to explain the course material to one another.			0.83	
Classroom Climate: Classroom Bias				
I have been singled out in this class because of my identity (such as race/ethnicity, gender, sexual orientation, disability status, religious affiliation, etc.)				0.84
I feel I have to work harder than other students to be perceived as a good student				0.59
In this class, I have heard my peers express stereotypes based on race.				0.95

In this class, I have heard my peers express gender stereotypes.						0.88		
In this class, I have heard my peers express stereotypes based on socioeconomic class.						0.95		
Classroom Climate: Classroom Comfort								
I feel comfortable sharing my own perspectives and experiences in this class							0.93	
I feel comfortable contributing to class discussions.							0.93	
Engineering Self-Efficacy (pre-test)								
I can succeed in an engineering major								0.72
I can complete the math requirements for most engineering majors								0.71
I can succeed in an engineering major while not having to give up participation in my outside interests								0.63
I can excel in an engineering major during the current academic year								0.72
I can succeed (earn either an A or B) in an advanced physics course								0.73
I can complete any engineering degree at this institution								0.62
I can succeed (earn either an A or B) in an advanced math course								0.72
I can complete the physics requirements for most engineering majors								0.66
I can succeed (earn either an A or B) in an advanced engineering course								0.8
Eigenvalue	5.19	4.94	3.55	2.9	5.38	3.63	1.71	4.45
Percentage of variance	65%	71%	71%	97%	67%	73%	86%	49%
Construct reliability	0.92	0.93	0.89	0.98	0.93	0.9	0.83	0.88

To measure student-centered teaching, I utilized the Student-Centered Teaching Scale created by Lattuca and Terenzini (2012) for students of engineering programs. The eight questions ask how often the instructor engages in certain teaching methods. Students respond using a 1-5 scale, where 1 = never and 5 = very often.

To measure instructor inclusivity and classroom inclusivity, I adapted questions from Gasiewski et al. (2012), Simon et al. (2017) and Litzler et al. (2014). The sixteen questions (divided into eight question sections) ask students to assess the instructor's behavior in creating an inclusive classroom environment. Students responded using a 1-5 scale, where 1 = strongly disagree and 5 = strongly agree. A factor analysis of classroom inclusivity created two factors: Learning-Centered Environment and Instructor Bias. The factor analysis of classroom inclusivity is in Appendix L.

The classroom climate scale is adapted from Hurtado et al. (2015) and supplemented with questions from the classroom climate scale used by the University of Michigan CRLT for its Foundational Course Initiative (Inclusive Teaching for Lecturers Departmental Feedback, n.d.). The seven questions ask about students' perception of inclusive/exclusive behaviors by instructors in the classroom. Students respond using a 1-5 scale, where 1 = strongly disagree and 5 = strongly agree. A factor analysis for classroom climate created two factors: Classroom Bias and Classroom Comfort. The factor analysis is in Appendix M.

Dependent Variables.

Classroom Sense of Belonging, Engineering Self-efficacy, and Desire to Remain in the field were the outcome variables in the study. I utilized the classroom sense of belonging scale, developed for the University of Michigan's Foundational Course Initiative in partnership with the Center for Research on Learning and Teaching. Information on the psychometric properties of the initial scale is in Mosyjowski et al. (2017). The eight questions in the scale ask students about their relationships with other students in their classroom. Students responded using a 1-5 scale, where 1 = strongly disagree and 5 = strongly agree.

The Engineering Self-efficacy scale combined two engineering self-efficacy subscales developed by Concannon and Barrow (2009). Together the subscales include 10 questions which measure students' academic milestones and their confidence in completing the engineering curriculum. Students responded using a 1-5 scale where 1 = strongly disagree and 5 = strongly agree.

Desire to remain in the field was measured by a categorical variable that asked, "How likely are you to change your major before graduation?" Students responded using a 1-6 scale where 1 = very likely, 5 = very unlikely, and 6 = don't know yet/not applicable. Because the question did not have enough variability, meaning that most students selected "very unlikely" and "unlikely" to change their major, the variable thus did not have sufficient variation (i.e., statistical strength) to be included in the quantitative data analysis.

Information on Interview Participants and Survey Sample.

In this section I briefly describe the study samples for the qualitative and quantitative strands of the study. For the qualitative strand, group interviews ranged from two to five participants. except for two interviews done separately with a Black/Latinx woman and a Black man due to not having enough people for those groups. A total of 69 students participated in the group interviews. For ChE 101 I conducted a total of 11 group interviews with 37 students; for ChE 201 I conducted 10 group interviews with 32 students. In both courses, I intentionally oversampled women compared to men. I created separate groups based on gender and race/ethnicity. ChE 101 had three groups of White men (8 students) and four groups of White women (15), three groups of Asian women (10), one group of Latina and Black women (3), and one Black man. ChE 201 had two groups of White and a non-identified man (6) and three groups of White women (11), two groups of Asian women (5) and one group of Asian men (3), one group of Black and Latino men (2) one group of Black and Latina women (4), and one Black/Latina woman interviewed separately. See Table 3.3 for demographic info.

Table 3.3

Demographics of Interview Participants

Trait	Count	Percentage
Course		
ChE 101	37	54%
ChE 201	32	46%
Gender		
Woman	49	72%
Man	20	28%
Race/Ethnicity		
White	39	55%
Asian	18	26%
Black	5	8%
Latinx	5	7%
Black/Latinx	1	1%
Unidentified	1	1%
Total	69	100%

Table 3.4 shows the student demographics of the survey sample. Within the sample, all students were chemical engineering majors except one student who reported as a biomedical engineering major. Of the total 170 respondents, 42% were students enrolled in ChE 101 while 58% were enrolled in ChE 201. The sample included 45% male, 54% female, and 1% non-binary students. Self-reported race/ethnicity was 6% Black, 25% Asian American/Pacific Islander, 51%

White, 6% Hispanic/Latino, 6% Multi-racial, 2% Middle Eastern. One student indicated no preference for race. In terms of citizenship, 94% were U.S. Citizens while 3% were permanent residents and 4% were international students. Parental degree was used to define first-generation status. Within the sample, 85% of students reported at least one parent had a bachelor's degree or higher while 15% had a parent with an Associate degree or less. Most students were second- or third-year students (83%).

The two non-binary students and one student who did not identify their race were excluded from the analyses due to sample size. Six international students were also excluded from the multivariate data analyses because of their potentially varied interpretations and ideas about gender and race. The final analytical sample included 161 undergraduate students.

Table 3.4

Descriptive Statistics for Analytical Sample from Surveys

Demographics	Frequency
Course	
ChE 101	99 (41.76%)
ChE 201	71 (58.24%)
Sex	
Female	91 (45.83%)
Male	77 (54.17%)
Non-Binary	
Race	
White	86 (50.59%)
Asian	42 (24.71%
Black	11 (6.47%)
Multiracial	11 (6.47%)
Hispanic	10 (5.88%)
Middle Eastern	3 (1.76%)
International	6 (3.53%)
Unknown	1 (.59%)

Parental Degree	
Some High school/High school	11 (6.47%)
Some College	16 (9.41%)
Bachelor's Degree	57 (33.53%)
Master's Degree	47 (27.65)
Doctoral Degree	39 (22.94%)
Class Year	
2nd Year	79 (46.47%)
3rd Year	63 (37.06%)
4th Year	20 (11.76%)
5th Year	5 (2.94%)
6th Year	1 (.59%)
Transfer	2 (1.18%)

Note: N=170. Sample includes the students that were eventually excluded. Students in the analytical sample completed both the pre- and post-survey.

Data Analysis

Because my study incorporates mixed methods, I began the analysis of the data by analyzing it separately and subsequently, comparing and contrasting the results (Hanson et al., 2005). This was done by developing themes from the qualitative data and comparing the themes to the quantitative survey results. The data analysis in this study includes inductive analysis of qualitative data and factor analysis and linear regression analysis of quantitative data.

My qualitative analysis process began as I used my instructor and group interview data (transcripts and memos) and observation data (jottings and summaries) to develop a codebook. I developed *a priori* codes related to the theoretical constructs that inform my study which includes teaching practices, instructor inclusivity, classroom inclusivity, classroom climate, sense of belonging, engineering self-efficacy, and desire to remain in the field. Once I began coding, I added open codes based on new emergent information from the interviews and observations.

I developed a single codebook for the instructor and group interviews, since some codes were the same, such as codes related to social identity. But I also identified separate codes for each when necessary. For the initial instructor interview, I developed codes around the instructor's goals for the course, their attitudes and beliefs about teaching, the educational environment they intended to create, and their beliefs about successful engineering students. Codes for the second interview with the instructor also included codes about their altered expectations, their perception of the classroom environment, their interaction with students outside the classroom, their approaches to inclusivity, tensions in the classroom, and the impact of their social identity on their teaching.

For the group interviews with the students, codes centered around students' sense of engineering self-efficacy, their perceptions of the classroom climate in relation to both instructor and peers, their experiences in course-based groups, and the impact of their social identity on the classroom experience. Codes for the observations included the different instructional methods that were used as well as patterns of student engagement.

I utilized an auditor to ensure consistency and clarity in the coding schema. The auditor was a woman Ph.D. student with training in both mechanical engineering and engineering education research. In addition, the auditor had taken courses in qualitative research and possessed subject knowledge regarding the topics in the research. I met with the auditor and we reviewed my list of codes and my research questions. Then she utilized my codebook to begin the process of coding the transcripts. The auditor and I met after she finished coding a group of sample transcripts that varied by course, ethnicity, and gender. She provided me with copious notes indicating which important codes she felt were missing and codes that she felt were confusing. As a result, I made some adjustments to my codebook adding new codes as needed after reviewing the transcripts again. Codes were entered into the Nvivo software program. Query reports of the codes were reviewed, and memos were written to identify broader themes within the data. The codebook is located in Appendix N.

Analysis of Observation Data.

As I engaged in capturing notes and jottings during the class sessions, I also reflected on my research question: "What is the nature of the learning environment the instructor plans to establish and enacts during the course?" I used my notes and jottings from the observation protocol to write weekly summaries after attending class sessions. As I wrote my summaries, I began to develop an understanding of the course context and the type of learning environment that was being created by the instructors and the students. At the end of the term, I read through the notes, jottings, and summaries to begin my reflection and analysis of the observations and to understand any changes in dynamics in the classroom. I then coded the summaries, reading through my notes and jottings line by line to identify patterns that captured my reactions and ideas of connections across the data (Miles et al., 2014). I used my codes to identify "emergent patterns, categories and subcategories, themes, and concepts" that were in the data (Saldana, 2009, p. 32). After I identified categories, I engaged in developing integrative memos to develop themes that emerged from the data (Emerson et al., 2011, p. 172). I then began to make connections in the data to determine how the themes connected to theory.

Instructor and Group Interviews.

After each instructor interview and group interview, I documented the data collection in summary form. Following this summarizing process, I coded the transcripts of the interviews.

After coding, I identified categories that linked codes, and ultimately themes that emerged within and across the interviews. To draw comparisons and contrasts between the instructors' approaches to students and teaching, I developed a variable-by-variable matrix to determine the interrelationships within the data (Miles et al, 2014). These types of connections particularly between what the instructors did in the classroom, the instructors' perceptions of what they did, and the students' perceptions are important to identify interrelationships within the data which helped me answer the following research questions: How do students perceive the learning environment? How do students' perceptions of the learning environment relate to students' engineering self-efficacy and course sense of belonging? How does engineering self-efficacy and course sense of belonging relate to desire to remain in the field? Do perceptions of the learning environment, engineering self-efficacy, course sense of belonging, and desire to remain in the field vary by gender? Do these vary for women based on race/ethnicity? To capture the concept of engineering self-efficacy but also to ensure I was using terms familiar to undergraduate students, I did not use the term self-efficacy in the group interviews. Instead, I asked students whether they felt more or less capable in succeeding in their engineering courses and the chemical engineering major.

Analytic Memos.

I engaged in an analytic memoing process throughout the study to capture my initial thoughts and emerging interpretations and questions (Charmaz, 2014). The process of analytic memoing encouraged me to reflect on the research questions as I gathered data and identified emergent patterns and themes (Saldana, 2009). As I reflected on my own experiences as a woman navigating engineering culture, memoing connected my own personal experiences with the participants. In the later stages of analysis, I utilized the analytic memos to bring together different parts of the data into general concepts (Miles et al., 2014).

Quantitative Analysis.

The two outcome dependent variables used in the analysis are scale measures of students' reports of engineering self-efficacy and classroom sense of belonging. The third outcome variable, desire to remain in ChE, was not utilized because nearly all students indicated that they were likely or most likely to continue in the chemical engineering major. Table 3.5 and Table 3.6 shows the courses and the students' responses to the desire to remain in the field questions at both pre- and post- time points. Students who responded "N/A/I don't know" are not included in the tables.

Table 3.5

Desire to Remain in ChE: Pre-Survey

Course	Yes	No	Total
ChE 201	68	3	71
ChE 101	95	3	98
Total	163	6	169

Table 3.6

Desire to Remain in ChE: Post Survey

Course	Yes	No	Total
ChE 201	69	2	71
ChE101	94	2	96
Total	163	4	167

I was not able to address one of my research sub-questions due to the low sample size of women of color: Do these (engineering self-efficacy, classroom sense of belonging, and desire to remain in the field) vary for women based on race/ethnicity? Although, I was able to run an analysis on race by combining the responses of both men and women of color (of which there were more) into one variable.

The four main independent variables were also scale measures of students' reports of student-centered teaching, instructor inclusivity, classroom inclusivity, and classroom climate. All scales in the study were evaluated using confirmatory factor analysis (CFA) because they derive from tested and validated instruments. According to Byrne (2012) "the researcher postulates a model and then tests for its validity given the sample data" (p. 95).

Factor Analysis.

I used principal components factor analysis for all the independent (student-centered teaching, instructor inclusivity, classroom inclusivity, classroom climate) and dependent (engineering self-efficacy, sense of belonging) variables. Of the independent variables, student-centered teaching (8 items) had primary loadings over .75 with an alpha of .92; instructor inclusivity (7 items) had primary loadings over .77 with an alpha of .93. Classroom inclusivity was placed into two factors. The first factor was named learning-centered environment and included five of eight items while the second factor named instructor bias had the remaining three items. Learning-centered environment had loadings over .71 with an alpha of .89 while instructor bias had loadings over .97 and an alpha of .98. Classroom climate was also divided into two factors. The first factor, classroom bias, had five out of seven items and had loadings over .59 with an alpha of .9. The second factor, classroom comfort, included two items and had loadings over .93 with an alpha of .83.

The dependent variable, classroom sense of belonging was originally 11 items but was reduced to eight items. Three items that were adapted from Pintrich et al.'s (1991) Peer Learning

Scale from their Motivated Strategies for Learning Questionnaire (MSLQ) were added to the sense of belonging measure but were removed (working together, studying together, discussing work together) because of their low loadings (under .62). After removing these items, the final classroom sense of belonging scale (8 items) had primary loadings over .76 with an alpha of .93. Although engineering self-efficacy was initially a 10-item scale, one item, "I can complete the chemistry requirements for most engineering majors," was removed from the scale because of the low primary loading of .55 at the first time point of engineering self-efficacy. Because the students were chemical engineering majors, the question seemed unreliable since most students had completed chemistry pre-requisites before taking their engineering courses. The alpha increased after removing this item. The final engineering self-efficacy scale had nine items and at the first time point had primary loadings over .63 with an alpha of .87. Engineering self-efficacy at the second time point had primary loadings over .66 with an alpha of .9.

Internal consistency for the scales was tested using Cronbach's alpha. The alphas for all the scales were high, .81-.99. According to Taber (2018), a Cronbach's alpha of .70 or greater is considered to have a high reliability. Refer to Table 3.1 for all scales and reliabilities.

Synthesis of Qualitative and Quantitative Data

In this section I provide an explanation as to how the qualitative and quantitative data are synthesized. Table 3.7 shows the relationship with the research question to the data sources, the independent and dependent variables from the quantitative data and the sensitizing concepts from the qualitative data.

Table 3.7

Relationships Between Research Questions and Data Sources

Research Question	Data Sources and Analyses	Variables and Sensitizing Concepts
Research Question 1: What is the nature of the learning environment the instructor plans to establish and enacts during the course?	Qualitative Data: • First Instructor Interview • Second Instructor Interview • Classroom Observations Qualitative Analyses: • Coding and Thematic Analysis	• Teaching Practices • Beliefs about Inclusivity • Interactions with Students • Beliefs about Engineering
Research Question 2: How do students perceive the instruction provided?	Qualitative Data: • Group Interviews Qualitative Analyses: • Coding and Thematic Analysis	• Teaching Practices • Classroom Climate
	Quantitative Data: • Student Post-Survey Quantitative Analyses: • Table of Means • Factor Analysis • Linear Regression Analysis	• Student-Centered Teaching • Instructor Inclusivity • Classroom Inclusivity
Research Question 3a: How do students perceive the learning environment?	Qualitative Data: • Group Interviews Qualitative Analyses: • Coding and Thematic Analysis	• Classroom Climate • Classroom Inclusivity • Instructor Inclusivity
	Quantitative Data: • Student Post-Survey Quantitative Analyses: • Factor Analysis • Linear Regression Analysis	• Classroom Climate • Instructor Inclusivity • Classroom Inclusivity

Research Question 3b: How do perceptions of instruction influence their perceptions of the learning environment?	Qualitative Data: • Group Interviews Qualitative Analyses: • Coding and Thematic Analysis	• Teaching Practices • Classroom Climate • Instructor Inclusivity • Classroom Inclusivity
	Quantitative Data: • Student Post-Survey Quantitative Analyses: • Factor Analysis • Linear Regression Analysis	• Classroom Climate • Student-Centered Teaching • Instructor Inclusivity • Classroom Inclusivity
Research Question 4: How do students' perceptions of the learning environment relate to students' engineering self-efficacy and course sense of belonging?	Qualitative Data: • Group Interviews Qualitative Analyses: • Coding and Thematic Analysis	• Teaching Practices • Instructor Inclusivity • Classroom Inclusivity • Classroom Sense of Belonging • Capability in Course and Confidence in Engineering
	Quantitative Data: • Student Pre-Survey • Student Post-Survey Quantitative Analyses: • Factor Analysis • Linear Regression Analysis	• Classroom Climate • Student-Centered Teaching • Instructor Inclusivity • Classroom Inclusivity • Classroom Sense of Belonging • Engineering Self-Efficacy
Research Question 5a: How does engineering self-efficacy and course sense of belonging relate to desire to remain in the field?	Qualitative Data: • Group Interviews Qualitative Analyses: • Coding and Thematic Analysis	• Capability in Course and Confidence in Engineering • Classroom Sense of Belonging • Desire to Remain in the Field

Research Question 5b: Do perceptions of the learning environment, engineering self-efficacy, course sense of belonging, and desire to remain in the field vary by gender?	Qualitative Data: • Group Interviews Qualitative Analyses: • Coding and Thematic Analysis	• Classroom Climate • Capability in Course and Confidence in Engineering • Classroom Sense of Belonging
	Quantitative Data: • Student Pre-Survey • Student Post-Survey Quantitative Analyses: • Factor Analysis • Linear Regression Analysis	• Classroom Climate • Classroom Sense of Belonging • Engineering Self-Efficacy • Gender
Research Question 5c: Do these vary for women based on race/ethnicity?	Qualitative Data: • Group Interviews Qualitative Analyses: • Coding and Thematic Analysis	• Classroom Climate • Capability in Course and Confidence in Engineering • Classroom Sense of Belonging
	Quantitative Data: • Student Pre-Survey • Student Post-Survey Quantitative Analyses: • Factor Analysis • Linear Regression Analysis	• Classroom Climate • Classroom Sense of Belonging • Engineering Self-Efficacy

In the following section I describe how each part of the data collection matches to each research question.

Research Question 1. What is the nature of the learning environment the instructor plans to establish and enacts during the course?

This research question explored the learning environment the instructor sought to create for students through the instructor interviews (pre and post) and the classroom observations. I utilized my observation summaries and the coded interviews with the instructors to construct my understanding of the classroom environment each instructor created, either intentionally or unintentionally. My first chapter of findings presents the ways the instructors engaged in their teaching practices, their beliefs about inclusivity, their beliefs about engineering, and their interactions with students.

Research Question 2. How do students perceive the instruction provided?

Data on students' perceptions of the environment came from the group interviews and the student surveys. Using the quantitative data, I utilized both factor analysis and linear regression to identify relationships between the variables. Factor analyses were used to determine reliabilities for the scale variables used in the linear regressions. I then created frequency tables to examine the means on key variables by gender and race/ethnicity and course; given limitations of sample sizes for women and men of color, this allowed me to see any notable differences for students of a specific gender and race. Data from the group interviews provided detailed information on students' reactions to specific teaching practices they encountered and their perceptions of classroom climate.

Further, I compared and contrasted the qualitative and quantitative data from these sources to analyze and portray students' perceptions of instruction (i.e., student-centered teaching, instructor inclusivity, classroom inclusivity), patterns related to gender and/or race ethnicity and to instructors' teaching practices, and how these affected students' experiences in the courses.

Research Question 3a. How do students perceive the learning environment?

I also attended to how evidence from the interviews compared to what I learned from the survey-based measures of the educational environment. (i.e., the measures of student-centered teaching, classroom climate, instructor inclusivity, and classroom inclusivity) and from the instructor interviews. Both the survey data and group interviews provide answers to this question. The data from the group interviews was utilized to understand how students perceived the classroom environment, specifically the classroom climate and areas related to both instructor and classroom inclusivity. I also utilized regression analysis to measure the relationships between classroom climate, instructor, and classroom inclusivity.

Research Question 3b. How do perceptions of instruction influence their perceptions of the learning environment?

Data from the group interviews provided insight into how students' perceptions of teaching practices influenced their perceptions of classroom climate, instructor, and classroom inclusivity. I utilized linear regression analyses to identify statistical relationships among students' perceptions of the classroom climate, instructor inclusivity, and classroom inclusivity as well as the relationship between the student-centered teaching variable and those variables.

Research Question 4. How do students' perceptions of the learning environment relate to students' engineering self-efficacy and course sense of belonging?

For my analysis of the influence of the classroom experience on students' socioemotional outcomes, data from the group interviews provided context and understanding of the learning environment. Additionally, sensitizing concepts for this analysis included teaching practices, inclusivity, classroom sense of belonging, and capability in the course and in engineering. The regression analysis measured the relationships among students' perceptions of the engineering classroom environment (i.e., classroom climate, student-centered teaching, instructor inclusivity, and classroom inclusivity) and the dependent variables (i.e., engineering self-efficacy and classroom sense of belonging).

Research Question 5a. How does engineering self-efficacy and course sense of belonging relate to desire to remain in the field?

I was not able to answer this question quantitatively since there was insufficient variation in the desire to remain in the field variable. However, the qualitative data, provided an understanding of how students' perceptions of classroom sense of belonging and their capability and confidence, although somewhat different constructs than self-efficacy, affected their desire to remain in the field.

Research Question 5b. Do perceptions of the learning environment, engineering self-efficacy, course sense of belonging, and desire to remain in the field vary by gender?

The survey data provided a broad understanding of women's perceptions of the engineering classroom environment while the qualitative data provided more specific details regarding the connections among these key concepts. In my statistical analyses of the survey data, I used variables from the factor analyses and conducted a linear regression analysis that examined variations by gender. Differences and convergences in the qualitative and quantitative data provide a more complete picture of the effects of the engineering educational environment on women.

Research Question 5c. Do these vary for women based on race/ethnicity?

Due to limitations in survey sample size, the qualitative data was used to understand how intersectional identities (women by race/ethnicity, men by race/ethnicity) shaped students' perceptions of the engineering classroom, engineering self-efficacy, and classroom sense of belonging. A regression analysis that combined survey responses from men and women was used to determine differences by race.

Validity and Trustworthiness

Using interviews, observations, and surveys provided a means of between-method triangulation (Denzin, 1989), thus increasing the validity of my work. According to Denzin, combining methods highlights each method's strength while overcoming weaknesses in each method. In addition to triangulating data sources, I employed a variety of methods to ensure the quality of my research process. First, I wrote summaries after each observation based on my notes and utilization of the observation protocol. I captured specific times of important interactions and occurrences that I perceived to be relevant to my research purposes. I also memoed after the group interviews and after the interviews with the instructors to encourage self-reflection on any biases that were influencing the study.

My awareness of my subjectivity is integral to my research (Peshkin, 1988). As a former academic advisor in Engineering and Computer Science, I have experienced sexism toward me by faculty in administrative positions and have witnessed sexism directed toward others in the work environment. I view these experiences as a strength in my research because according to Harding (2005), subjectivity in research can increase objectivity when it prompts the researcher to be transparent about influences that could have affected the results of the study. However, I may not always be aware of my own subjectivities. I therefore used peer debriefing with my dissertation supervisor and a small group of colleagues who have experience in engineering research to ensure my interpretations made sense.

I also used an auditor to assess the transparency and quality of my codes and my application of them and shared and discussed my preliminary and later analyses with my dissertation supervisor to deepen my understanding. I also engaged in member checking with the instructors to ensure that I captured their thoughts and reflections accurately.

Limitations

Limitations also exist in this study. Both time and resources prevented a larger multi-institutional, multi-classroom study but this study can provide a template to be replicated and to inform future studies. Further, the goal of the study is not generalizability, but greater understanding of how social identities may shape students' experiences in the engineering classroom.

The use of group interviews with students, rather than individual interviews, limited my ability to discuss the impact of social identities on students' experiences of instruction in greater detail. On the other hand, group interviews can have advantages; in my study, students seemed to feel comfortable sharing their experiences and views about certain topics when other students spoke up. The group interviews also created opportunities for conversation among students, which prompted more reflection about the questions I asked. In my group interviews, there were multiple occurrences in which one woman in a group spoke up about her experience with sexism in engineering which prompted other women in the group to agree and then tell their own stories.

The onset of the COVID-19 pandemic necessitated that I conduct my research online. This allowed me limited means of observing students' body language in class when the instructor was teaching. The instructors also explained that they felt quite drained from their teaching, and one might surmise that they might have engaged in different types of active learning techniques in a face-to-face course. My qualitative data showed that several students indicated that they did not feel there was much of a difference between the online delivery of the course compared to in person since both courses were mostly "lecture," but there were some students that disliked the nature of the online courses which could have skewed some of the overall results of my survey and potentially shaped the discussions of their experiences in the two courses.

Chapter 4 Quantitative Findings

Overview of Conceptual Framework

The conceptual framework that guides this study assumes, based on literature, that aspects of science and engineering culture, such as the values placed on meritocracy, objectivity, and neutrality, as well as a history of patriarchy, infiltrate engineering classrooms. I recognize that there are individuals that do not perceive engineering culture in this way but for the purpose of my study and because of the focus on marginalized students, engineering culture was assumed to be toxic. These cultural values are manifested by instructors and men peers, and potentially by women students as well. Specifically, the framework assumes that engineering culture shapes both instructors' pedagogy and their interactions with students, as well as students' interactions with their peers in the classroom. Accordingly, women's interactions with instructors and peers shape their perceptions of the classroom climate, instructor inclusivity, and classroom inclusivity. These perceptions then affect their classroom sense of belonging, engineering self-efficacy, and desire to remain in engineering (a measure for persistence). This conceptual framework thus informs the quantitative methods that were utilized in this study.

Survey Results

Quantitative data in this study came from a pre- and post-survey administered electronically (using Qualtrics survey software) to students in both courses. The pre-survey was distributed during the first and second week of class while the post-survey was distributed at the end of the course. Upon advice from a statistical consultant, I combined data from both courses because although there were differences in some of the means, they were small in magnitude. Any differences within the tables of means represented minor differences between small numbers of student participants in the survey and thus did not affect the results of the regressions.

General Interpretation of Means of Variables

Descriptive statistics for ChE 101 and ChE 201 located in Table 4.1 and Table 4.2, respectively, reveal some notable patterns in both courses. In both courses, women were overrepresented and students that identified as White and Asian were also highly represented. ChE 101 had more student participants (n=99) than ChE 201 (n=71), but it was also a larger course. The means for student-centered teaching, instructor inclusivity, learning-centered environment, classroom comfort, and classroom sense of belonging were slightly higher in Roger's course than Amar's course. Students in Roger's classroom were more engaged than in Amar's classroom, keeping their cameras on and unmuting to ask questions often which may have contributed to Roger's course having higher means.

The variables instructor bias and classroom bias, which were both reverse coded, had higher means in Amar's course than Roger's course meaning that students disagreed more strongly in Amar's course that there was any instructor or classroom bias. Amar's course involved group work where students were able to self-select into groups which many students discussed as a positive experience. This may be why students indicated that there were low levels of bias from the instructor or their classmates.

Notably, engineering self-efficacy in Roger's course increased amongst almost all populations of students except Black men and one multiracial student. In Amar's course, multiracial students, Black students, and White women did not experience increases in post-self-efficacy means. Yet, the total means of pre- and post-self-efficacy reveal that students in Amar's course entered with higher levels of self-efficacy than in Roger's course. Higher entering levels of self-efficacy in Amar's course may be due to students' status as third- and fourth-year chemistry majors who had already passed many difficult engineering gateway courses. Yet, students in Amar's course had lower means of post-self-efficacy compared to Roger's course in which students' self-efficacy increased after taking the course. Because the study did not intend to evaluate each course but rather to understand relationships among variables, I combined the data from both courses.

Table 4.1

ChE 101 Means of Independent and Dependent Variables by Gender and Race/Ethnicity

Demographic Variables	Independent and Dependent Variables									
	n	Student-Centered Teaching	Instructor Inclusivity	Classroom Inclusivity: Learning-Centered Environment	Classroom Inclusivity: Instructor Bias[a]	Classroom Climate: Classroom Bias[b]	Classroom Climate: Classroom Comfort	Classroom Sense of Belonging	Pre-Engineering Self-Efficacy	Post-Engineering Self-Efficacy
Women	53	4.68	4.73	4.78	4.64	4.55	4.12	4.35	3.78	3.97
Men	46	4.73	4.77	4.74	4.59	4.43	4.25	4.31	4.09	4.35
Non-Binary	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White	53	4.77	4.82	4.83	4.6	4.51	4.24	4.32	3.97	4.18
Asian	22	4.64	4.69	4.73	4.64	4.5	3.98	4.44	3.91	4.14
Latinx	5	5	5	4.96	4.01	4.4	4.8	4.45	4.02	4.2
Black	8	4.27	4.32	4.4	4.63	4.2	3.63	3.81	3.6	3.85
Multiracial	3	4.67	4.9	4.73	5	4.6	4.67	4.92	4.19	4.33
White women	26	4.75	4.8	4.83	4.6	4.62	4.25	4.36	3.81	3.95
Asian Women	19	4.62	4.66	4.73	4.58	4.43	3.95	4.44	3.82	4.08
Latina women	0	0	0	0	0	0	0	0	0	0
Black women	4	4.44	4.82	4.9	5	4.75	4	3.78	3.53	4.03
Multiracial women	1	4.75	4.86	4.8	5	3.8	5	4.75	3.56	3.11
White men	27	4.79	4.85	4.82	4.59	4.41	4.22	4.28	4.12	4.4
Asian men	3	4.75	4.86	4.73	5	4.87	4.17	4.46	4.48	4.56
Latino men	5	5	5	4.96	4.07	4.4	4.8	4.45	4.02	4.2
Black men	4	4.09	3.82	3.9	4.25	3.65	3.25	3.84	3.67	3.67

Multiracial men	2	4.63	4.93	4.7	5	5	4.5	5	4.5	4.94
Average Means		4.14	4.21	4.2	4.12	3.95	3.77	3.89	3.5	3.66

Note. $N = 99$

[a] Items were reverse-coded

[b] Items were reverse-coded

Table 4.2

ChE 201 Means of Independent and Dependent Variables by Gender and Race/Ethnicity

Demographic Variables	Independent and Dependent Variables									
	n	Student-Centered Teaching	Instructor Inclusivity	Classroom Inclusivity: Learning-Centered Environment	Classroom Inclusivity: Instructor Bias[a]	Classroom Climate: Classroom Bias[b]	Classroom Climate: Classroom Comfort	Classroom Sense of Belonging	Pre-Engineering Self-Efficacy	Post-Engineering Self-Efficacy
Women	38	3.93	4.12	3.97	4.51	3.99	3.66	3.81	3.99	3.9
Men	31	4.13	4.36	4.23	4.54	4.36	3.98	4.09	4.18	4.23
Non-Binary	2	4.75	4.86	4.7	5	5	3.75	4.06	4.67	4.33
White	33	4.14	4.22	4.1	4.43	4.13	3.92	4.12	4.08	4.04
Asian	20	4.18	4.44	4.29	4.5	4.33	4	3.83	4.16	4.18
Latinx	5	3.83	4.2	4	4.47	3.84	3.4	3.8	4.02	4.11
Black	3	3.58	4	3.87	5	4.67	3.33	3.96	4.3	3.81
Multiracial	8	3.66	3.91	3.7	4.79	3.85	3.13	3.41	3.99	3.86
White women	19	4.07	4.09	3.98	4.28	3.94	3.82	4.09	3.95	3.77

Asian Women	9	3.88	4.21	4.09	4.7	4.31	3.78	3.42	4.06	4.14
Latina women	2	3.31	3.93	3.7	4.5	3.8	2.75	3.56	4.28	4.33
Black women	1	3.88	4.43	4.2	5	4.4	4	4.38	4.67	4.44
Multiracial women	6	3.75	4.07	3.8	4.78	3.5	3.25	3.4	3.91	3.81
White men	14	4.23	4.4	4.26	4.64	4.39	4.07	4.17	4.25	4.41
Asian men	9	4.35	4.57	4.4	4.19	4.2	4.28	4.19	4.14	4.19
Latino men	3	4.17	4.38	4.2	4.44	3.87	3.83	3.96	3.85	3.96
Black men	2	3.44	3.79	3.7	5	4.8	3	3.75	4.11	3.5
Multiracial men	2	3.38	3.43	3.4	4.83	4.9	2.75	3.44	4.22	4
Average Means		3.93	4.19	4.03	4.64	4.24	3.59	3.86	4.16	4.06

Note. $N = 71$

[a] Items were reverse-coded

[b] Items were reverse-coded

Linear Regression

Based on my conceptual framework, I assumed that students' perceptions of the instructors' pedagogy (student-centered teaching) and learning environment, as measured by the instructor inclusivity, instructor bias, learning-centered environment, classroom bias, and classroom comfort variables influenced their classroom sense of belonging and engineering self-efficacy. Although I had intended to measure persistence through the desire to remain in the field variable, I was not able to include it because of the lack of variability of the measure. I assumed that any relationships I found may vary by students' gender and their race/ethnicity. I had hoped to perform an intersectional quantitative analysis in which I examined whether engineering self-efficacy and classroom sense of belonging varied for women based on race/ethnicity but was unable to do so due to the small sample sizes for the various gender/race groups in the study. Instead, I have included a general race/ethnicity variable in the regression analysis reported in this chapter.

I estimated five ordinary least squares regression models to measure the association between the independent variables (student-centered teaching, instructor inclusivity, instructor bias, learning-centered environment, classroom bias, classroom comfort) with the dependent variables which included classroom sense of belonging, pre-engineering self-efficacy, and post engineering self-efficacy. I also constructed another dependent variable: change in self-efficacy to determine whether any differences in self-efficacy were significant. Other variables of interest in the models included race, gender, and parental degree. Six international students, two non-binary students and one student who chose not to identify their race were excluded from the sample (n=161).

Table 4.3 shows the results of the first regression analysis. In the first model, I assumed that student-centered teaching would have a relationship with the other learning environment variables (instructor inclusivity, classroom bias, instructor bias, learning-centered environment, classroom comfort) as well as the dependent variables, classroom sense of belonging and engineering self-efficacy. As per this assumption, I regressed student-centered teaching on instructor inclusivity, instructor bias, learning-centered environment, classroom bias, classroom comfort, and pre- and post- engineering self-efficacy. Although the results showed no significance between the demographic variables or the dependent variables, there was a relationship with two other independent variables: instructor inclusivity and instructor bias. Both measures had positive significant relationships ($p<.001$) with student-centered teaching. On average, a one-point increase in student-centered teaching was associated with a .41 and .47 increase in instructor inclusivity and instructor bias, respectively. Of note, the instructor bias variable was reverse coded meaning that higher reports on the scale indicate lower levels of instructor bias.

Table 4.3

Relationship between Student-Centered Teaching, Control, Independent and Dependent Variables

Variables	*b*	*SE*
Female	-0.04	0.05
White/Asian	-0.09	0.06
Some high school/high school	-0.03	0.13
Classroom Sense of Belonging	0.03	0.04
Instructor Inclusivity	0.41	.1***
Instructor Bias	0.47	.09***
Learning-Centered Environment	-0.04	0.04
Classroom Bias	0.03	0.05
Classroom Comfort	0.04	0.05

Pre-Engineering Self-Efficacy	-0.09	0.06
Post-Engineering Self-Efficacy	0.03	0.06
r2	0.77	

Note: *N*=161. Significance levels: p < *0.05, **0.01, ***0.001

Table 4.4 shows the results of the second regression analysis. In the second model, I regressed classroom sense of belonging on student-centered teaching, instructor inclusivity, instructor bias, learning-centered environment, classroom bias, classroom comfort, and pre- and post-engineering self-efficacy while controlling for race, gender, and parental degree. Results indicated that none of the demographic variables were significantly related to classroom sense of belonging. Yet, the classroom comfort measure had a positive significant relationship (p<.001) with classroom sense of belonging. On average, a one-point increase in sense of belonging was associated with a .54 increase in classroom comfort. The post-engineering self-efficacy variable also had a significant relationship (p<.05) with classroom sense of belonging. Therefore, for every one-point increase in sense of belonging, there was a .29 increase in engineering self-efficacy.

Table 4.4

Relationship between Classroom Sense of Belonging, Control, Independent and Dependent Variables

Variables	*b*	*SE*
Female	0.07	0.11
Asian	-.04	0.13
Some high school/high school	0.03	0.27
Student-Centered Teaching	0.11	0.17
Instructor Inclusivity	-0.12	0.21
Instructor Bias	-0.13	0.19
Learning-Centered Environment	-0.11	0.08

Classroom Bias	-0.17	0.1
Classroom Comfort	0.54	0.08***
Pre-Engineering Self-Efficacy	-.1	.11
Post-Engineering Self-Efficacy	.29	.11*
r2	0.45	

Note: *N*=161. Significance levels: p < *0.05, **0.01, ***0.001

Table 4.5 shows the results of third and fourth regression analyses, which assessed the relationship with pre- and post-engineering self-efficacy with classroom sense of belonging, the classroom environment independent variables, and the demographic variables. In the third model, I regressed the pre-measure of engineering self-efficacy (taken at the beginning of the course) on student-centered teaching, instructor inclusivity, instructor bias, learning-centered environment, classroom bias, classroom comfort, and classroom sense of belonging controlling for race, gender, and parental degree. Identifying as female (p<.05) had a negative relationship with engineering self-efficacy. On average, females reported self-efficacy 0.24 points less than males.

Table 4.5

Relationships among Engineering Self-Efficacy, Control, Independent and Dependent Variables

	Engineering Self-efficacy	
Variables	**Model 1: Pre** ***b***	**Model 2: Post** ***b***
Female	-0.24 (.1)*	-.17 (.08)*
Asian	0.01 (.12)	.13 (.09)
Some high school/high school	0.01 (.24)	.09 (.19)
Student-Centered Teaching	-0.25 (.15)	.06 (.12)
Instructor Inclusivity	.24 (0.19)	.04 (.15)
Instructor Bias	-.15 (0.17)	.06 (.14)
Learning-Centered Environment	-.06 (.07)	-.07 (.05)

Classroom Bias	.08 (.09)	-.03 (.07)
Classroom Comfort	.13 (.08)	.12 (.07)
Classroom Sense of Belonging	.05 (.07)	.15 (.06)*
r2	0.15	0.53

Note: *N*= 161. Significance levels: p < *0.05, **0.01, ***0.001

In the fourth model shown above in Table 4.5, I regressed the post-measure of engineering self-efficacy (taken at the end of the course) on student-centered teaching, instructor inclusivity, instructor bias, learning-centered environment, classroom bias, classroom comfort, classroom sense of belonging, and pre-engineering self-efficacy and controlled for race, gender, and parental degree. Identifying as female (p<.05) had a negative relationship with engineering self-efficacy while classroom sense of belonging (p<.05) had a positive relationship. On average, women's self-efficacy was -.17 less than males' engineering self-efficacy. On average, a one-point increase in engineering self-efficacy was also associated with a .15 increase in classroom sense of belonging. Noticeably, in the post-test measure, women's engineering self-efficacy had a slightly less negative relationship than the pre-test measure while classroom sense of belonging increased compared to the pre-test.

Table 4.6 shows the results of the final model. I created a variable that measured the change between the measure of self-efficacy at time 1 and the measure of self-efficacy at time 2. I regressed the self-efficacy change variable on student-centered teaching, instructor inclusivity, instructor bias, learning-centered environment, classroom bias, classroom comfort, classroom sense of belonging, and controlled for race, gender, and parental degree. The change in women's self-efficacy from the first time point to the second time point was not found to be significant. Yet, there was less difference in the second measure of self-efficacy (t=-2.49) compared to the first measure (t=-2.11). It is possible that change of self-efficacy is not significantly different than that of men because men may also be experiencing a change in self-efficacy.

Table 4.6

Change in Self Efficacy between pre- and post-survey with Control, Independent and Dependent Variables

	Change in Self-efficacy	
Variables	b	SE
Female	-0.07	0.09
Asian	0.12	0.10
Some high school/high school	0.10	0.22
Student-Centered Teaching	0.17	0.14
Instructor Inclusivity	-0.07	0.17
Instructor Bias	0.12	0.15
Learning-Centered Environment	0.09	0.06
Classroom Bias	-0.07	0.08
Classroom Comfort	0.06	0.07
Classroom Sense of Belonging	0.13	0.07
r2	0.20	

Note: *N*=161. Significance levels: p < *0.05, **0.01, ***0.001

Discussion

The quantitative data results indicated that students' perceptions of instructor's use of student-centered teaching proved to have a relationship with instructor inclusivity and low instructor bias. This reveals that the pedagogical methods instructors enact in the classroom appear to be connected to students' perceptions of instructor inclusivity which includes the positive ways they felt the instructor treated them such as making the classroom environment comfortable to ask questions in class and making them feel that they could succeed in the course. Positive student-centered teaching the instructors engaged in also appeared to have a relationship with less instructor stereotyping based on gender, race, and socioeconomic status. This finding reveals that what the instructor does pedagogically in the classroom matters to whether students feel included in the classroom. The qualitative data in this study, which is presented in the next chapters, discusses how student-centered teaching influenced how students perceived the classroom climate and their perceptions of instructors' inclusiveness.

The data presented also showed that students' sense of comfort in the classroom, such as comfort sharing perspectives in class and comfort contributing to class discussions had a relationship with sense of belonging. In the following chapters, I report on similar findings from the qualitative data analysis, in which women participants indicated that comfort was key to their feeling a sense of belonging to the classroom community. Comfort with the instructor and their teaching did appear to also contribute to women feeling more capable and confident in engineering.

A relationship was also discovered between classroom sense of belonging and post-engineering self-efficacy. The qualitative data did not clearly provide evidence of the relationship between sense of belonging and engineering self-efficacy, but literature indicates potential relationships between the two variables (see Verdín, 2021). Also, I did not ask specific questions in the group interviews regarding whether or not their sense of belonging contributed to their feelings of capability. Rather, I asked a broad question that asked if they felt more or less capable of doing chemical engineering after taking the course. Therefore, students were not asked to make a connection between their sense of belonging and capability they felt in the course.

Engineering self-efficacy was negatively associated with identifying as female at the pre- and post-test. The qualitative data illuminates the finding of women's low self-efficacy; many women in the group interviews discussed having negative beliefs about their abilities in engineering even before taking these courses. Although I did not find the change in engineering self-efficacy to be significant, the qualitative data reported in the following chapters, although not assessing self-efficacy but rather the similar constructs of capability and confidence, reveal that both men and women reported increased levels of confidence and capability after taking the courses. This may explain why the change in self-efficacy was not statistically significant because the change for women may have been similar to men's increase in self-efficacy.

Another reason may be because women's self-efficacy means were different for both courses. Women in Roger's class had higher averages of post-engineering self-efficacy while women in Amar's course had decreased averages. This may be connected to the different workload. Roger's course did not have exams and the students felt the assignments were manageable. In Amar's course, he gave exams, homework, and students had to complete their in-class problems. At the beginning of Amar's course, students complained to Amar that the workload was unmanageable, so he cut down the amount of homework problems. Yet, students still felt that the work was quite challenging which may have contributed to students' self-efficacy. Another finding at the post-test of engineering self-efficacy was a relationship with classroom sense of belonging. This finding furthers the argument based in literature that there may be a connection between sense of belonging and engineering self-efficacy which should be further explored.

The next three chapters present the qualitative findings of this study which provide additional insight into the quantitative findings presented in this chapter. The in-depth analysis of the group interview data also provides qualitative evidence to support the assumed relationships within my conceptual framework. Chapter 5 discusses the role of engineering culture in the classroom and how instructors adopted and went against these cultural pressures. Chapter 6 presents findings regarding women's beliefs about their abilities in engineering and students' perceptions of the classroom climate, the instructors' student-centered teaching, and classroom sense of belonging. Finally, Chapter 7 discusses students' perceptions of their capability and confidence in the courses and their desire to remain in the field of chemical engineering after taking the courses.

Chapter 5 Qualitative Findings of Instruction

Overview of Courses and Instructors

I initially consulted with the Chemical Engineering Department undergraduate advisor to identify instructors who might be willing to participate in my study, which included classroom observations and interviews with their students during the course. Specifically, I asked the advisor to recommend two instructors that engaged in active learning. My belief was that active learning would provide opportunities to observe interactions between students and the instructor and the potential for observing inclusive teaching practices. The advisor recommended Amar who taught an advanced ChE course (ChE 201) and Roger who taught a gateway course (ChE 101). She indicated that many students had shared with her that they enjoyed taking their classes. She was not sure if they engaged in active learning but had heard good things about both instructors. The Chemical Engineering Department consists of 27 full-time tenure-track instructors and only about 2-3 courses using a large lecture format are offered per semester. Therefore, these two courses appeared to fit the criteria for my study. I reached out to Amar and Roger and they were eager to commit to the study. Both courses were conducted online due to the ongoing COVID-19 pandemic.

Table 5.1 outlines key patterns regarding the inclusive teaching practices Roger and Amar attempted to integrate into their classrooms. Roger and Amar’s inclusive practices are pertaining to broad areas that are important aspects of inclusive teaching which include instructor self-awareness, interactions with students, and curriculum and instruction.

Table 5.1

Instructors' Alignment with Inclusive Teaching Practices

	Roger	Amar
Beliefs about Inclusivity	• Aware of **patriarchal behaviors in engineering** among students and colleagues • Self-awareness of **unconscious bias** • Acknowledge **race/gender privileges** and his role as an "elder statesman"	• Aware of widespread assumption that scientists are **all White men**. • Aware of the need to have **diverse representation** in engineering
Interactions with Students	• **Did not talk down to students** but treated them as equals • **Listened and addressed** student needs regarding the content and quizzes	• Emphasized **wanting students to feel included** in the engineering community • Intentional about **getting to know students personally** during office hours • **Did not talk down to students** but treated them as equals • **Listened and addressed** student needs regarding timing of exams and shortening problems
Inclusive Practices	• **Incorporated DE&I** into course content and curriculum • **Gave formative feedback** through multiple try quizzes disseminated regularly • **Used positive reinforcement** when students answered/asked questions • **Invited students** to participate by pointing out that even he felt the work was difficult	• Made **in-class examples more inclusive** by showing diverse representation of scientists • **Used positive reinforcement** when students answered/asked questions • **Invited students** to participate by pointing out that even he felt the work was difficult

I present data in the next sections on the two courses I observed in sequential order with Amar's interview and classroom observations discussed first with Roger's analysis following. In each section of the instructors, I will provide descriptions of the instructors and their pedagogical beliefs, then I will present data form the initial interviews I conducted before the course began and data from the second interviews that were conducted once the course had concluded. Finally, I will provide a brief overview of what I observed in the classroom regarding the instructors' behaviors and teaching practices.

CHE 201: Amar

Amar identifies his racial/ethnic background as Indian and White but identified mostly with Indian. During the time period for my study, Amar's course was an advanced course composed of many students nearing graduation. The structure of the course, which had been previously created by a different instructor, included a lecture component and in-class problems that were completed in student groups after the lecture session. Because Amar was pre-tenure, he took his course evaluations very seriously; he shared that he went through them and made changes based on student feedback. Amar expressed a passion for teaching the content of the course because he felt the concepts required problem-solving and were important to engineering. He explained how learning problem-solving in engineering connected to real life situations and reflected on what he thought were good questions for students to ask themselves, "What do you think will happen, and how do you extrapolate, and how do you use information that you have previously, including mathematical information to predict what's going to happen is a good way of approaching problems in life."

Amar had attended the same institution he was teaching at and had taken the course he was teaching during my study when he was a student. He told me it was one of his favorite courses and that it had influenced his career decisions in engineering. He shared that "it gave me a lot of confidence in my abilities to understand things in the world. And so, I think that's a powerful tool." He believed the course he was teaching was the "heart of chemical engineering" and felt it was important that students understood how to apply their conceptual and mathematical understanding to everyday situations. It was important to Amar that students sharpened their problem-solving skills so that they could be prepared to be successful in their professional engineering careers.

Beliefs about Inclusivity

Amar set clear expectations regarding classroom etiquette and how students should treat each other. Amar explained that he had an overall desire to make his classroom inclusive because he wanted all students to feel they were part of the engineering community. After consulting with the engineering student affairs center, he used specific inclusive language to lay out expectations for his students that included "how they are treated by other students, how they should feel comfortable with talking to me if they like, oh, the other student is treating them poorly or making them feel unwelcome in the course". Amar, as shared in the initial interview, reviewed his diversity statement in class and told the students that he wanted an inclusive classroom, wanted students to feel comfortable, and if they did not feel comfortable, to speak to him. He went a step further telling the students that they could reach out to a different faculty member if they were not comfortable talking to him. In our initial interview, he shared his overall thoughts about inclusivity,

> Everybody that's in the class belongs in the class, and it's unacceptable for any student or me as the professor to say or do anything that makes people feel discriminated against or makes people feel unwelcome in the classroom environment.

When our discussion shifted to how he worked with students who were having difficulty in his courses, Amar explained, "I want everybody to feel that they can do it, but also I think for chemical engineering, I think there are components too that are very difficult, and the students are like, ‘yeah, I don’t want to do this.’” He explained that he did not believe in convincing students to stay in the major if they hated it. He believed that while some students that are struggling need some encouragement to get through, there are students who simply do not like the major and no longer want to pursue it. Amar reflected on how he responded to these varying needs of students and how he offered support,

> If someone says, "Oh, I don't think I'm good enough to do it," obviously, I say, "Yeah, I think you're capable of doing this." But if someone says, "I hate this, I don't want to do this. I wanted to quit for many years." I'm not going to tell them, "Oh, suffer through it." I don't really think that's a good way. I understand, especially now with COVID stuff, there's a higher degree of maybe mental health concerns that might be affecting it.

Amar also shared that in the past he had not intentionally reached out to students who seemed to be struggling in class because he assumed those students typically did not want to stay in the major. Although, recent conversations in his department seemed to persuade him that he should reach out to students that were not performing well to see if something was wrong.

Interactions with Students

At the end of the course, Amar shared that he was disappointed that so many students chose not to have their cameras on during class but understood that every student had different situations which may have prevented the use of their cameras. Typically, in class, there were one to three students out of around 65 students that kept their cameras on. He indicated that when he taught in person, he relied on “reading” students’ faces and could identify points of confusion to determine if he needed to review a concept or not. He was also able to get to know students on a first name basis. He felt the course was less personal because many students kept their cameras off, which prevented him from getting to know them. He only knew the students who came to his office hours which he shared was “unfortunate because when they graduate, I like having some idea of who the people are.” He also shared that the instructional tools he used to engage students such as Zoom polls (a substitute for clickers) took longer in Zoom, which he had not anticipated. As a result, he had to adjust the in-class problems that he gave to the student groups after the lecture section of each class.

The one area he appreciated in the online environment was office hours. His office hours were heavily attended, and he felt there was much more learning occurring than in previous office hours that were held in person. He shared his thoughts about this: “for me, I looked forward to those [office hours] more, because I was like, oh now I’m going to get some of the students one-on-one, usually they have their video on, I can ask questions and see what they’re up to.” Amar felt office hours helped him confirm if students were understanding concepts and paying attention in class.

Amar had minimal involvement with the student groups as they worked on their problems. He was not aware of any issues that had been brought to his attention but acknowledged that there may have been issues that happened that he was not made aware of. Amar sent out emails in the beginning of the course asking students if they wanted to change their group assignments, but he never heard back from anyone. He added that he also had minimal involvement with the groups when courses were in person and let the GSIs answer most of the questions raised in these sessions.

Reflecting in our final interview about this online version of the course, Amar said that the performance of students in the course was not “terribly different” than the previous year. Yet he acknowledged the additional challenges, such as the elimination of a spring break, which he sensed caused more student struggles. As a result, he changed some assignments because he, too, struggled with the pace and keeping up as well. He noticed that the students were much more fatigued than the previous year and he was cognizant of the students needing to take care of their physical and mental health needs.

Inclusive Practices

Prior to my study, Amar invited teaching and learning consultants to evaluate his teaching to determine how he could make his course more inclusive. He explained that he did so because he felt his course was one of the most important classes for students in chemical engineering. He enjoyed the possibility of having an impact on future engineers, “I feel like this is something that's, to me, these people are going to go out and do stuff in this space that's going to help society and help the future. And I get to teach them how to do it.” As a result, he received feedback on how to solicit questions from students and how to respond to student answers. He kept up with the chat function, repeating the questions and answering the questions while often using the students’ names. I observed this in the classroom many times; when students would pose questions, Amar would say the student’s name and read the question out loud while often commenting that it was a good question. He enjoyed using the chat function because he thought it was easier for both him and the students to help with the flow of class. He felt he had more control in the course since he could see the questions and determine whether he should stop or address the question in the next section of class.

Amar was also told by the teaching consultants to express to the students the difficulty of the material while also telling them they should have questions. For example, during class, Amar would say “this is really tricky” or ‘I’ve struggled with this” before soliciting questions from the students. When going over exam grades, Amar told them that the exam was supposed to be challenging and if they did not do as well as they expected on the exam, that they should not feel disheartened and as if they are behind. He told them that they still had opportunities to improve their grade and could still go on to be “great chemical engineers”.

Amar also indicated that he wanted to improve on making examples in his teaching more inclusive:

> I try to make an effort that when we’re talking about a chemical engineer, it’s not like this is the specific type of person that’s a chemical engineer. All of the people in the classroom, you are chemical engineers, you’re going to become chemical engineers. And try to make that clear.

In one class session he discussed instructors in the chemical engineering department and their specialties which included White women and a Black woman on his slides. When asked about this, he indicated that he had a student email him the previous year sharing that she appreciated seeing “people in chemical engineering that are diverse,” so he included a diverse array of instructors. He believed that visualizations of people who are not in the “historical majority” are important, saying,

> If you're putting images very consistently to people that oh, this is a chemical engineer, they're doing really well, and they only see that, that's quite different than maybe once. But if it's a consistent thing, I think ... and even just reinforcing more, there's a diverse group, all of you are going to be chemical engineers and tell people that.

Finally, acknowledging the different needs of students, he shared that he did not feel he should project his perspectives onto the students. He shared that when he was an undergraduate engineer, he felt he was part of the engineering community and wanted others to feel the same way. He told me, “It wasn’t really like, ‘There’s someone exactly like me there,’ but it was like, if you do this stuff and you understand it, you’re part of the community.”

Amar's Classroom

Much of what Amar shared with me in our interviews was evident in my observations. Amar showed aptitude in using technology for teaching. In the very first class he emphasized his passion for the topic he was teaching in engineering and talked about his experience in the course and its impact on him. He emphasized that students should ask for help as there were many resources presented in the course. He also signaled his willingness to be flexible and to help students as he did not want to overburden the students with the course. I observed him encouraging the students as he recognized that the problems were challenging. Often in class he would use validating responses to student questions such as "great question!" and "good question!" He also emphasized his desire to have an inclusive classroom and encouraged students to talk to him if they had any issues.

Often Amar interacted with his slides, drawing pictures, underlining, and circling. Every morning he wrote "good morning" on the slides and would greet students as they entered the virtual classroom. Then he would proceed to share announcements or other important info for the students to know. He was very quick to respond in the chat and once a student sent a question, he would immediately address it. He used organizational markers (slides with bullets) to review, introduce new concepts, and review what they covered in class. He also utilized Zoom polls frequently. Sometimes he would incorporate real world examples that included topics such as fertilizer and soap. In class, he would also ask questions, requesting that students place the answer in the chat. Every class he worked out problems as the students followed along asking students questions or providing answers to their questions.

ChE 101: Roger

Roger identifies as a White man and is a tenured instructor who has been at the university for many years. He served as the department chair for several years and had not recently been teaching courses. During my study, the course he was teaching was in a lecture format, and due to the pandemic, offered virtually. Roger did not administer exams but rather assigned weekly quizzes that students completed to get points toward their grade. He explained this decision was based on giving students the content for the exam and “give them enough problems so that they can practice those so that by the time they're done, they feel confident that they know what's going on.” He also understood that the students had other courses and other things going on in their lives and he did not want to overwhelm them particularly because of the nature of the ongoing pandemic. He knew that some students would not enjoy the content as much as he did.

Roger felt responsible for keeping students engaged in his course. He believed that students had the responsibility to do the assignments and take the course seriously. He did not assign group projects in the course because he felt he needed to focus on “trying to cement some fundamental understanding of something that they’re going to deal with for the rest of their lives as engineers.” Roger said he focused on making sure students were understanding the concepts rather than focusing on learning how to interact with other people in groups.

Roger also explained his approach to teaching as “tell them and then tell them what you told them,” instead of taking a flipped classroom approach, of which he was not a fan. He shared that when he was Department Chair, he asked students if they enjoyed the courses they were taking that were “flipped” and the students shared that they hated them. As a result, he decided not to use a flipped classroom approach for any of his courses. Roger was also clear that he never used aspects of active learning in his teaching, yet, in my classroom observations I noted that he often used instructional approaches associated with active learning, including group discussions, asking students for input, polling, drawing pictures, and providing examples using hand motions or demos.

Roger appreciated being able to look at students' reactions to his teaching so he could determine if he needed to stop or move forward with the material. He made it clear in class that he welcomed students keeping their cameras on so he could see their faces and determine if people were confused or not. According to my observation notes, about one-third of the class kept their cameras on regularly. Roger also solicited feedback on his lectures from students in the first few weeks of class and took their suggestions as long as they were reasonable.

When asked about the learning environment he tries to create, Roger shared that he was not focused on creating a learning environment but wanted to work with the students to take their feedback and make any necessary changes. Because Roger had not taught in some time, he had compiled ten teaching points that he had planned to implement in the course and had planned to have the teaching and learning consultants determine if they were "pedagogically correct." He created the points by searching on the internet and reading articles. The points included putting key points in a coherent structure, spacing out learning, teaching in short bursts, encouraging students to get sleep, providing immediate feedback, and providing opportunities to learn in different ways. During his interview, I pointed out that he seemed to be creating a learning environment. He agreed and added that he had certain expectations of his students as well to create a learning environment. He respected the students' time and expected them to respect his time as well. He also found it important to inject humor in his lectures to make sure students stayed awake. He felt it was important to be "collaborative, that I'm constantly engaging the students." He also explained that he answers "all questions, and if I don't have time, I just say we'll continue next time with these questions".

When discussing the important skills engineers needed to have to be successful, he said communication and collaboration, as well as problem-solving skills, were important. He explained that in engineering there are often many ways to get the "right" answer and he felt that "there's a whole host of what you put into that process, making sure you treat everybody fairly, that you're not abusive to anyone, that you are respectful of everyone, that you don't mock anyone." He explained that he tries to model certain behaviors in class by not talking down to the students. He elaborated, "I don't say well, you're all stupid and really can't understand this. I'm much smarter than you because I have more degrees. I would never say anything like that."

Although a tenured professor, Roger indicated that he still cared about his teaching evaluations since they offered a means of curating feedback and determining how to adapt his class. He also implemented course assessments during the course, administering surveys in the beginning of the course and in the middle that asked students if they wanted more quizzes or less and when they wanted quizzes released. When students shared that they were overwhelmed with other courses, he offered to scale back quizzes to support their needs. He also awarded course credit for students completing the surveys to increase participation. He was adept at utilizing the newest technology in his classroom and shared how he was unafraid to try new things since he was toward the end of his career. He explained this further, "I feel a lot more freedom to try things because if I get bad teaching evaluations this year, that will hurt my feelings, but I'll at least know that I have tried something and I'll be able to improve it the next time."

Beliefs about Inclusivity

Roger shared that he did not like teaching first-year graduate students because they often tried to show off with each other and demonstrate to the instructor that they were the smartest of the group through “gamesmanship.” He explained that this was reflected in engineering’s status as a male-dominated profession. He shared his concern that there is “a lot of testosterone in the room. It's just poisonous, so I don’t teach those classes anymore.”

In creating the curriculum for his undergraduate course, Roger worked with a group in the department of Chemical Engineering focused on equity and inclusion to develop quiz and homework problems to include in class. He discussed what the content would include, providing an example: “so distributing water resources to low-income communities or anything that might look at economic disparity, racial disparity, gender disparity, anything that comes across as an equity issue and an inclusion issue.”

Roger admitted that he had low tolerance for any students that engaged in inappropriate behavior. When asked about things he may have witnessed in the past connected to gender or racial discrimination, he explained that he had witnessed more issues with faculty,

> I've had faculty tell me, ‘Well, women this, women that.’ and I said, ‘that's offensive, that's sexist.’ ‘Oh no, it isn't!’ and I've never had someone say ‘Gosh, thank you! I really understand it now.’ They always deny it and argue against it.

He also commented on how in some cases he also witnessed attempts at discriminatory hiring practices where he had to step in and say something.

Interactions with Students

Roger had reviewed literature on teaching before he decided on the course structure and the decision not to give exams. He did not understand why instructors would often try things without reviewing the literature first, observing that within the discipline of chemical engineering, experiments are never conducted without first reading and researching. He shared disappointment that other faculty members would not structure a course like he did with limited-try quizzes and no exams: “I started this about a year ago working on this, and it makes me sad knowing that no other faculty member would do this. I'm just insane, right, to actually take on that much work for no reward.” He felt that other instructors would not be able to replicate what he did because of the extensive time it took to develop the quizzes. Roger reflected on his decision to give the students quizzes instead of exams and felt that it reduced students’ stress levels. In our final interview, he felt satisfied with the outcome of the course overall: “I firmly believe it's the right way to do it, right? The students responded exactly how I hoped they respond. This is so much less stress for me. I hope they learn better, and I think they did.” He further explained his satisfaction about his decision to not administer exams, “I think it just felt more professional, more respectful to the students rather than, ‘I am God-like, and you will do this test and that'll be that.’"

To make his classroom welcoming, Roger made sure that after any student asked a question he often stated, “that’s a good question.” His goal was to encourage students to speak up during class. He also thanked students for reaching out when they sent him emails with questions. He explained why he engaged in this type of behavior, “I'm trying to make them on the same level as me or at least that we're, if not colleagues, at least we are both going for the same goal.” When asked about why it was important for him to treat students as equals, he explained that it was the way he was treated by his chemistry instructor in high school, and he appreciated the relationship he was able to have with his teacher. As a graduate student in engineering, he had interacted with a faculty member that valued interactions more with students than Nobel Laureates. He shared how he viewed these interactions,

> So, I saw a very flat structure from his interactions, and I thought that was great. I said, ‘yes, that [pisses] me off when there's a lot of hierarchy’, and so, I just, I tend to treat the students with as much respect as I can and welcome them into the learning environment with me.

Roger reported that although he reached out to three students that were at the bottom of the class, they did not respond to him. Overall, he felt that he had fewer issues with students having difficulty in this course because he believed the structure of the course was less stressful for them. According to Roger, half of the class would probably end up getting A’s which was unlike any time he taught before. He indicated that he was not concerned about giving out a large number of A’s because he felt that the students had learned the content and the grade distribution was similar to other courses he had taught in the past. That distribution included a small portion of students who failed the class while the rest passed.

Roger felt the virtual experience was draining but at the same time he expressed appreciation that the class felt smaller since he had a group of about 30 students that kept their cameras on. He was able to keep the pace by looking at their expressions and answering their questions. He explained that the students who appeared to be engaged were also the top students who had good questions, caught his mistakes, and noticed slight subtleties in the concepts. Roger shared that in his prior experiences in face-to-face courses, the vocal students were not always the top students and sometimes he had to take time out of class to tell students to see him after class. In contrast, he said, in this course, the students helped lead his teaching.

Because Roger relied heavily on observing student body language when in person, he found it difficult to easily “read” the students in the virtual environment, which contributed to him feeling drained after classes. Because the course I was observing was online, Roger shared that he felt disconnected to the students and that made him sad. Roger also felt that he had to put in more work than an in-person course. He explained that it took more planning and organization to do things like setting up a Zoom poll whereas in person he could ask students to raise their hands. Although Roger held office hours, they were not heavily attended. He explained that they were very similar to in-person office hour sessions, and that he liked the virtual office hours more because there were less people, allowing him to easily read their body language through the camera.

On the last day of class, I observed the students holding up signs to thank Roger for a great course. It was evident that Roger was emotional about this. When asked about this afterwards he shared that he was shocked and surprised when they did this. He had never experienced anything like it in any other courses. He indicated that in past in-person courses, sometimes students would clap on the last day of the course, but he had never experienced students holding up signs to thank him.

Inclusive Practices

When asked about his incorporation of DE&I into his course, Roger explained the tension he felt about integrating DE&I into his curriculum. He confessed the fear he had of receiving pushback from students because of arguments that DE&I does not belong in engineering. He elaborated on this, saying it is not often done in engineering courses,

> I think most of what I did was exposing them to situations, and I often felt nervous about that. I feel like where or how a chemical plant is operating and how, where it's situated and its impact on the neighborhoods nearby is extremely important to consider, but I don't know whether all the students would agree that's part of the curriculum. They would say, "Well, that's not [ChE 101]. You shouldn't be teaching that." I was nervous and I'm

> still nervous that I might get, there might be legal ramifications for what I did. That's just how I feel. I feel nervous, I feel scared.

Yet, Roger was “hoping that they would get an exposure to decisions outside of numbers and calculations, that in the end, everything they do affects people, and it disproportionately affects some people rather than others.” It was important to him that the students understood how society functions around unfairness. He said, “I wanted them to realize that the world was not fair and that they had to be cognizant of that, and they had to realize they were a part of it, they were a part of that unfairness.” In the end, he sensed that students appreciated the DE&I topics and discussions because students made positive comments in the course evaluations and he did not receive any complaints.

He also acknowledged that unconscious bias is prevalent in engineering and admitted that he has his own biases that he tries to correct. He shared that at one point in class when a Black woman asked a question, he made assumptions that she was struggling in the course. He explained his feelings around this, “I'm like, ‘Wow, why did I just think that?’ And I've thought that because she was African American, and that's horrible, but that's an unconscious bias I have that I have to actively work against.”

Roger led a discussion in the last class about unconscious bias. He explained the importance of assembling diverse teams in engineering and discussed how certain schemas (unconscious bias) exist based on race, gender, and sex. When Roger was discussing this during class, I observed a woman ask him how she should combat bias and he was unsure of how to answer. This prompted many women to begin talking to each other through the chat about their negative experiences as women. One woman shared that she had been told that she was only in the engineering program because she was a woman. This prompted women to offer messages of support and validation through the chat.

Roger also acknowledged in our final interview that he enjoyed an array of privileges as a White man. He expanded on this notion: “I realized that I'm privileged in teaching and that I can command respect, plus now I'm more of the ‘elder statesman’ which plays well when you're a man.” Roger confessed that he enjoyed his privileges because it made his job easier. When having discussions around racial inequalities, he felt that other White men in his courses would listen to him because it was a “stronger statement I think coming from me and I’m happy to do that because I believe in it.”

Roger’s Classroom

In the first class, Roger discussed the incorporation of DE&I into the course and explained his teaching and learning strategies. As I observed throughout the term, I noted that he consistently asked students at the beginning of class to have their cameras on because it helped him look at their faces to identify whether they were understanding or not. He would also use the first few minutes of class to solicit feedback from the students and to make announcements. Roger would then start with a review, introduce new concepts, then summarize what they did in class and cross off the topics covered. His slides had many pictures and diagrams, and as he taught, he would draw arrows, circles, write notes, and underline. Roger injected humor and personal anecdotes throughout the class. Often, students would add to his jokes in class. He frequently solicited questions from the students. He often forgot to respond to the chat as he lectured, so he eventually began to stop after each slide to review the chat to make sure he had addressed all the questions or comments.

My observations show that Roger would often respond to students' questions by saying "Good question!" "Great question!" Sometimes he would pose questions to the students or utilize Zoom polls. In addition, he paused after each slide to check the chat and to make sure the students had caught up copying down his notes and diagrams. He would watch the students to see when they would stop writing as a signal to continue. In every class, he would work through a complex problem with the students. During this, he would frequently stop and ask if students were understanding the concepts. Roger constantly used hand motions and real-world examples to describe concepts. During class he would often use cars as an example to discuss concepts related to fluids, and even apologized at one point in class for talking about them so much. In another class he described how the spread of COVID was connected to water molecules bonding together which made the virus spread easily through the air. Other days he used examples such as splashing water, pushing on a bucket, watching a wakeboard hit the water, placing paper in a sink and watching the water go down, and putting a paper and cup on a turn table to clarify concepts such as vorticity.

My observations indicated that many students were engaged in the course, often unmuting, or placing a question in the chat. Students also interacted with each other through the chat, asking questions to each other and answering them before the instructor caught up in the chat. Roger often had humanizing moments which revealed his awareness of his own imperfection. In one class, when a student asked a question about a problem, he stopped and said that he was going to have to do it after class because of the pressure of performing in front of a group. Another time he shared with the students that a concept was very confusing and that he too was confused for a very long time and still gets confused. He would often share anecdotes about his own struggles learning the material. He would also work out problems during class asking students questions as he went but also asking rhetorical questions as he explained the material such as “Do we want to do this?” or “Can we think of a way that this would work?”.

Tensions in Engineering Culture and Classrooms

According to Carter et al. (2019) meritocracy in engineering is the belief that innate talent and hard work will make you successful in the field. As a result, this meritocratic ideology breeds competition. Because STEM majors/careers are believed to be “high status” they are especially subject to competitiveness and a strong belief in meritocracy. Carter et al. explain that there is a general belief in engineering that if you are failing in engineering, you only have yourself to blame. Both Amar and Roger utilized teaching practices that went against meritocracy but at the same time also continued to have elements of meritocracy woven into their classes.

Both instructors in this study attempted to subvert aspects of engineering culture such as meritocracy, objectivity, neutrality, superiority, and patriarchy. Yet they also maintained beliefs around meritocracy, objectivity, and neutrality. Roger went against the notion of meritocracy by changing his course so that students would have more opportunities to succeed rather than fail by taking multiple-attempt quizzes rather than exams. But when I interviewed him, it almost seemed that he was convincing himself it was ok to give so many A’s out since it was not the standard in engineering. He made remarks about appreciating having “the best and the brightest” speak up during class compared to past courses where students who were struggling spoke up more. Amar went against notions of meritocracy through his belief that all his students had the potential to succeed and wanted to do everything he could to ensure they had help and support. This was evident in an interaction he had with a student who failed the first exam. He met with the student and gave him encouragement. When the student passed the second exam, Amar sent him an email to congratulate him on his success. Amar went against meritocratic values by believing the student could be successful rather than believing the student was not smart enough to do well in the course.

As noted, Roger included DE&I topics in his course, with two class topics on implicit bias and another on the impact of dams on marginalized communities because he felt it was important for students to understand for their future careers as engineers. He also integrated DE&I topics into the quizzes covering such topics as the Flint water crisis. Although he was attempting to combat beliefs about keeping the curriculum in engineering objective and neutral, Roger shared that he was fearful of repercussions, even legal challenges, based on these choices. Although Amar included diverse representation of engineers in class, he adhered to ideas of engineering about maintaining objectivity and neutrality. He took a "color-blind" approach believing that anyone could be an engineer as long as they did the work.

Both instructors had strong beliefs against instructor superiority and power dynamics. They both took collegial approaches with their students, and in my class observations I noted many instances in which they tried to ensure students felt comfortable with them and were not "talking down" to them. As a student, Roger had come to value relationships with instructors that treated him as an equal compared to instructors that did not and sought to act on this experience. Amar had been a student in the same course as the students he was teaching and wanted students to feel that they could speak with him and consult with him about anything.

Roger, too, specifically called out the culture of patriarchy in engineering and the negative behaviors he had encountered with men graduate students and other men in his department. He was keenly aware that men make degrading comments about women in engineering and that his attempts to correct them only led to defensiveness on the part of perpetrators. Amar was also aware most people in engineering viewed scientists as "old White men." He thus felt it was important to have diverse representation, but in our conversations he did not specifically address issues related to men's patriarchal behaviors in engineering.

Meritocracy

Amar challenged meritocratic ideology by his belief that all his students could succeed in engineering and that the only ones that could not were those that chose not to continue because they "hated" it. During class, Amar was encouraging to students telling them that they all had the ability to be engineers even if they did not do well on the first exam. Specifically, after the first exam Amar shared with the class that it was ok if they did not do well and that they could still go on to be great engineers. Yet, Amar still incorporated aspects of a meritocratic engineering culture by administering what he admitted were difficult exams that did not always match the homework problems while also grading on a curve.

Roger intentionally or unintentionally challenged this cultural meritocracy through his decision to forgo exams and give students multiple opportunities to complete weekly quizzes. He did this in the belief that students would feel less pressure as they learned the course material. Roger felt he had to justify his decision to forgo exams. At the end of the course, he realized he would be giving out more A's than he normally did although the general grade distribution was not much different than in other courses he had taught. He said he was "ok with that" because he felt the students learned.

Although the structure of Roger's course contrasted with meritocratic assumptions, he exhibited some personal beliefs related to meritocracy. For example, Roger placed value on students' apparent intelligence, sharing that the most vocal students in class are not always the "best and brightest" but he was fortunate in his current course because the students that asked questions, according to him, were extremely bright. Although he expressed this sentiment, he also showed concern for students at the bottom of the class, reaching out to them and even consulting with one student about taking an incomplete grade for the course.

Objectivity and Neutrality

Critical scholars discuss how science originated from the enlightenment which cultivated the idea that science should be pure and therefore objective (Cech, 2013; Harding, 1991; Ladson-Billings, 2000; Riley et al., 2009). Thus, attempts to incorporate marginalized viewpoints were viewed as a threat to science's role as objective and neutral. Roger's incorporation of DE&I topics was a clear disruption of engineering culture's value of neutrality and objectivity. He argued that engineering required aspects of DE&I and that students would benefit from these conversations.

In my observation, Roger did not impose his beliefs on the students but rather gave them information and said that they should consider the impacts of certain engineering projects on communities. But, by merely discussing DE&I he felt he was doing something drastically different than what is typically discussed in engineering courses.

In contrast to Roger, Amar did not incorporate any aspects of DE&I topics. He felt that all students that did the work should be welcomed into the engineering community no matter who they were. While Amar expressed a desire to be inclusive, his "color-blind" approach served to maintain assumptions of objectivity and neutrality, thus contributing to the potential marginalization of students who were doing the work but still being excluded from full participation in engineering. For example, even though he attempted to be inclusive through diverse representation of chemical engineers on his slides, there were two occasions where he showed a video on safety in engineering and a video explaining a specific concept in engineering. Both videos only had men actors while the safety video only featured men on a construction site.

Superiority

Both Roger and Amar had strong beliefs about how to treat students and viewed their role as instructors as working within a "flat structure", which is not typical in engineering culture. Historically, science's emphasis on objectivity has also given it a culture of superiority which can result in condescending and authoritative behaviors by those in places of power and privilege. Both instructors valued cultivating relationships with students. Roger specifically discussed how he was positively treated by instructors as an equal and sought to treat his students the same way. Amar also had positive experiences with instructors and wanted students to feel they were a part of the same engineering community as he was. Both instructors believed that having mutual respect was important in their classrooms. As I observed in the classroom, the instructors created a collegial community; they never talked down to students or said things that I perceived would cause the students discomfort.

Both instructors engaged in kind and accommodating behaviors also laying out clear expectations that made them less intimidating compared to other engineering instructors. Roger was transparent and honest with his expectations compared to other engineering instructors who had unclear expectations and who typically did not share with the students what they needed to know for an exam.

Patriarchy

Roger discussed aspects of a patriarchal engineering culture among men graduate students and men colleagues in his department. Roger chose not to teach men graduate students because there was a lot of “testosterone” and arrogance in graduate courses; he shared that men students often attempted to correct him in class. As noted, Roger also recognized how men in his department behaved, often making degrading comments about women. Yet, while Roger went against the patriarchal culture by discussing implicit bias, particularly toward women, when he was asked by a woman how to combat this, he was unable to give her an answer. That prompted other women in the course to provide thoughts and ideas using the chat feature.

Although I did not observe or hear that Amar acted to address patriarchal aspects of engineering culture, he shared his belief in the importance of broad representation in engineering. He made sure to include women in his slides when discussing engineering accomplishments particularly because a woman student pointed out she appreciated diverse representation of engineers.

Summary

Engineering culture and its emphasis on meritocracy, objectivity, and neutrality has also paved the way for superiority complexes and a patriarchal structure. Historically, engineering developed through the military which has a history of participating in the exclusion of women. Engineering is also viewed as a “high status” major and its rigor and culture of “weeding out” has made it exclusionary of those not in the majority. Although the instructors in both classes attempted to subvert meritocratic ideology, objectivity, and neutrality, they still maintained some beliefs consistent with these aspects of engineering culture. Yet they both felt strongly about developing a positive learning environment through their teaching. The way they enacted these plans in the courses was in tandem with their beliefs about teaching, inclusivity, and how they desired to interact with students.

Chapter 6 Qualitative Findings of the Learning Environment and Sense of Belonging

Engineering Culture's Effects on Women in the Classroom

Although the instructors in the two classrooms engaged in inclusive pedagogy, engineering values of meritocracy, neutrality/objectivity, superiority, and patriarchy persisted having effects on both men and women. Women's experiences with gendered and racial microaggressions, by men peers and other engineering instructors who embodied engineering values, contributed to women questioning their skills and abilities. Yet, the positive classroom climate that Amar and Roger cultivated through their versions of inclusive pedagogy made women participants in this study feel both comfortable and cared for in those classroom environments. Women participants' perceptions of an inclusive classroom climate along with their positive virtual peer interactions in Roger's course and group interactions in Amar's course helped create a classroom sense of belonging.

Table 6.1 outlines the key findings based on women's course perceptions. Women's course perceptions are reflected through their interactions with instructors and men peers in prior courses; they are also reflected in their discussion of classroom climate, inclusivity, and classroom sense of belonging.

Table 6.1

Key Findings of Women's Course Perceptions

Women's Course Perceptions	Key Findings
	• **Meritocratic values in classrooms** contributed to women's negative self-appraisal and low self-confidence

Other Courses: Interactions with Instructors	• Behaviors that reflected instructors' assumptions of **superiority in engineering classrooms** made women uncomfortable with participating in class or asking the instructor questions one on one.
Other Courses: Interactions with Peers	• **Gendered microaggressions** stemmed from men's patriarchal behaviors in which they made women feel negatively about their abilities. This included **being ignored and having ideas co-opted, mansplaining, and patronizing behaviors.** • Black women experienced **racial microaggressions** besides gender microaggressions by men peers and White women who did not believe they were competent and ignored them which led Black women to seek out groups that matched their intersecting identities so they could feel "safe". • **Women's acts of resistance** included calling out men peers for their negative behaviors or making it clear that negative treatment was not tolerated. Yet, these acts were sometimes met with men peers engaging in "gaslighting".
Focal Courses: Women's Social Identities and Self-Perceptions	• Women entered the classroom with **negative self-appraisal and low academic self-confidence** in their abilities to do engineering work and to be engineers. They feared making mistakes and being perceived as incompetent and were intimidated by their peers because they did not feel smart enough.
Focal Courses: Classroom Climate and Inclusivity	• Women found that the instructors showed **respect and collegiality** which made them want to participate and engage in the classroom. • Positive reinforcement, validation, and humor contributed to women's **comfort** in the classroom to participate, engage and attend class. • Women expressed **"feeling cared for"** by their instructors. They felt the instructors cared about their learning and about them overall through both personal and in-class interactions which made it feel like a classroom community. • Women appreciated the **integration of Diversity, Equity, and Inclusion** in Roger's class feeling that it was important for them to learn. • **Men peer's responses to Diversity, Equity, and Inclusion** reflected a color-blind approach and reflected desires for engineering to maintain neutrality and objectivity.
Focal Courses: Classroom Sense of Belonging	• **ChE 101: Virtual peer interactions** in Roger's course made women students feel that they were in a supportive community and positive classroom environment

- **ChE 201: Group interactions,** in which students self-selected, in Amar's course contributed to women feeling supported and connected to the classroom community.
- **Sexism and gendered racism in engineering groups** Women discussed negative experiences with men in groups and therefore sought to be in groups with other women. Black women intentionally sought out each other to create groups in which they could feel "safe".

This chapter explores how women's negative experiences in other engineering courses include exclusion, sexism, and gendered racism which contrasted with their perceived inclusion in the courses with Amar and Roger.

Perceptions of Instructors in Other Engineering Courses

Women discussed how instructors in past engineering courses engaged in a system of meritocracy (being tricky, grading on a curve, valuing toughness) that made them feel bad about themselves. They also discussed how instructors engaged in superior behaviors that made them feel demeaned and inferior.

Meritocratic Values in Classrooms

Both men and women in my study discussed the meritocratic values they experienced in engineering classrooms. In my group interviews, some women noted that instructors in engineering "like to be tricky" on exams and homework and "professors will put questions that aren't necessarily covered in lecture." A White woman discussed how she had previously had instructors that "really stretched what we actually needed to know, and it just increased the stress and didn't really do much for my understanding." The glorified "toughness" of engineering appears to contribute to its reputation as a "high status" field and may account for why engineering instructors engage in such negative practices. Despite creating difficult exams, instructors also graded on a curve, a method that participants viewed as designed to weed out students not viewed as “smart” enough to stay in the major. A White man in Amar’s course explained his discomfort with the curve system and confusion of how it connected to his future professional career,

> Our classes are so difficult, it's pretty disheartening, despite a curve, it's pretty disheartening to know that you're getting 50, 60, 70s, 80s on exams. And it's pretty confusing. Because, I don't really know right now, I don't have a scale of, what is actually expected of a chemical engineer in industry.

Students were also influenced by meritocratic values in engineering and struggled with Roger’s choice to use quizzes rather than exams in his course. Although many of those who participated in this study appreciated the absence of exams, some participants worried that by not taking exams they were at a disadvantage to other peers that took the course with exams and that their learning would suffer. They also expressed the opinion that students who were not in Roger’s course viewed it as an “easy” class and thus devalued those that were successful in it because the course was not “hard.” A Latina shared how students in a higher year level complained about how “easy” the course was for her,

> I have a lot of older friends in ChemE, and they're kind of like, ‘Oh, well, your fluids is such an easy class because of this reason and this reason. You guys are all going to get As.’ And I was like, I see where they're coming from. But in that way, it can be a little bit invalidating because it's like, ‘Oh, it's an easier format of the class.’ But overall, I still feel like I've learned a lot.

The beliefs expressed in this passage are consistent with Godfrey’s (2014) discussion about what engineering students value in their coursework. She explains that students are proud of being able to successfully complete challenging engineering coursework. Even as students experienced tensions with meritocracy in engineering culture most men and a small group of women participants in this study also expressed beliefs that were in line with meritocratic engineering culture. A White woman explained that she appreciated that her group members were similar to her in terms of intelligence,

> I just trust, I don't know how to say this in a good way, but I trust like the intelligence of my group members because I know them. And so, I feel as though I can really trust if they're telling me, "No, the way you're doing this, I think it's a good idea, but it's wrong." I believe them and I'm not defensive.

The view of engineering as being “high status” was especially shared by men, made evident here in how a White man described the responsibility of being an engineer, “As engineers we have a responsibility. We have a lot of accountability that comes with trying to revolutionize the world, but impacting people at the same time, whether good or bad.”

Superiority in Engineering Classrooms

Women described feeling inferior because engineering instructors behaved as if they were superior to students. A White woman shared how instructors can make students feel: “I feel like a lot of my previous professors have been very authoritative and like, I'm the professor and like do, as I say, and you guys are very below me.” Another White woman elaborated on how she is often treated by instructors from the department,

> Going to office hours from professors who have told me that they don't have time to answer my question and just being very rude about my questions, so I, for all my chemical engineering classes, don't go to office hours of the professor intentionally. The GSIs and IAs are always more helpful and don't make me feel like I'm stupid. I will never

> ask a question directly in class, just again, prior experience in our department of having professors not be receptive and being very degrading to students.

Many women participants explained the process of “shutting down” from participating in class due to instructors’ negative behaviors toward them. A Latina shared how instructors’ demeanor toward students discouraged her from participating in class:

> I'm in another engineering course where I 100% do not feel comfortable asking that professor a question, because I know I'm going to be met with a snarky remark or not necessarily mean, but not necessarily a positive reaction either.

Other women participants explained that some professors in other courses “act as if they know everything.”

Perceptions of Men Peers in Other Engineering Courses

Although women did not specifically identify instructors as engaging in patriarchal behaviors, they frequently discussed the way their men peers behaved and engaged in gendered microaggressions toward them. Through my interviews, women participants recounted how men peers used their power to dominate women and exclude them from groups. They relegated women to secretarial roles and often took credit for their work. Women participants reported that they were made to feel that they were not smart enough or capable enough which made them feel that they had to prove themselves constantly. They also felt both ignored and often patronized. The intersection of race and gender occurred for Black women when they encountered racial microaggressions by both White men and women. They were ignored and treated as incompetent and also had their ideas taken. This reveals that undertones of sexism and racism existed particularly for Black women.

Gendered Microaggressions

According to many women participants in my study, men appear to actively participate in patriarchal behaviors, whether subconsciously or consciously, that make women feel negatively about their abilities. Women in my study discussed experiencing gendered microaggressions and discrimination because of men peers' patriarchal behaviors. Several discussed negative classroom interactions with men peers based on their gender. A White woman summed up these general behaviors, "I would say in office hours in the past there have been some male counterparts who just encourage making us feel stupid as women." Another White woman shared her experiences based on her gender, "I think in previous classes, I have felt more discrimination or just little microaggressions being a female."

Some White and Asian men in the study acknowledged the privilege that their social identities afforded them in not encountering any issues of "mistreatment." Yet only one man in the study discussed how he engages in behaviors to provide a more comfortable space for women,

> I think as I've gone through college more, especially in engineering, knowing that I'm a male in engineering and that females in engineering do not have the same opportunities that I do, or more, based on how companies hire, but at least in the classroom being in male dominated rooms, I've been much more aware of that and tried to actively be less present in group settings.

Although one White man acknowledged the negative ways a woman on his team was being treated, he did not explicitly identify the issue as connected to gender. He shared that his friend, a woman, was getting talked over and ignored by someone on the team and it made him feel uncomfortable. Yet, when asked if he went to the professor, he shared that he thought about it but decided against it because he felt that it would just be "complaining." The student did not clarify if he recognized the group member's behaviors as veiled microaggressions toward the woman. Because patriarchy is embedded into engineering culture, men may not recognize negative behaviors toward women as gendered microaggressions.

Being Ignored and Having Ideas Co-opted.

Women participants reported that men in engineering often ignored women's ideas and then took them as their own. A White woman shared how men ignored her when she was the only woman in the group,

> I was the only girl in my group. And they like, I would give suggestions in our group chat and stuff and try to plan when we were going to work on it. And they pretty much ignored me. And then if I had suggestions while we actually finally did meet, they pretty much didn't hear my suggestions. So, it definitely takes your confidence down a little bit when people just don't take your suggestions seriously, and they don't even acknowledge that you are contributing to their group.

Another White woman shared her experience of being talked over and completely ignored in a group, an experience that made her choose an all-female group the next time around. Similarly, a White woman discussed how an all-men group ignored her by not including her and even meeting without her,

> I had a group project where I was the only girl in it, and they would not include me in anything. It got to the point where I had to ask, "Hey, when we are we meeting?" They would just be like, "Oh, we did it already." I'm like, "Okay, thank you. That's great."

Women's negative experiences in teams have been researched by Tonso (1996), who found that engineering cultural norms were translated into the negative ways men treated women in teams. Henderson (2021), in his recent study, found that engineering's culture of Eurocentrism and sexism dominated group interactions on design teams. Not only did women report being ignored, but they also found that their ideas were also often taken by men. A White woman expressed her frustration with getting cut off by a man who proceeded to take her idea:

> I have had an instance in discussion once where I was explaining something, got completely cut off by somebody else. And then what he proceeded to say was exactly the point I was trying to get at and it really undermined my point, and I was very frustrated in that moment.

Another White woman expressed her frustration with being ignored and having her ideas co-opted,

> Like if you say something, and then it just gets ignored. But then someone else says it, that's like a guy, and then it's a great idea. That's happened to me a lot. And that's really frustrating in small groups.

An Asian woman encountered a similar experience of having her ideas appropriated,

> So, in my intro to engineering classes, there's definitely been times where I had something to say to male members. They've told me, "Oh, that's kind of like a silly idea." Or they kind of ignore that idea. But then when the teacher came around, that was like the first thing out of their mouth -- my idea -- taking credit for that.

Another White woman shared: “I've had other engineering courses where my ideas are looked past or kind of thought of after a guy typically says their opinion.”

Besides men co-opting ideas, women also felt that men took credit for their work. A White woman shared her experience of putting in a lot of work into a project only to get pushed to the side by an arrogant man in the group while he took credit for her work,

> I've had a partner for a project, twice now, that I've been working with that from the get-go I could just tell that he was giving off, kind of like [names another student in group interview] said, arrogant, thought he was smarter than me because I was the only female in the group. I could go on for days about this because it's really annoyed me, but I spent a lot of time putting in the grunt work for the project and figuring out a lot of the theory and calculations behind it. Then it came down to when we were actually presenting the project and he gave me the introduction slide and then gave him and my other male partner pretty much all of the rest of the presentation. It just kind of felt like it was targeted because I was a woman.

Mansplaining and Patronizing Behaviors.

Many women discussed how men often second-guessed their work and engaged in "mansplaining" in which they were condescending and patronizing when explaining concepts to women. A majority of these experiences were discussed as happening in groups although women also discussed negative behaviors happening in class when they would raise their hand to answer or ask a question. A White woman explained how men looked over her work, "I would say it's just not second-guessing women, the girls in the groups work but not the guys, or guys reading over your paragraphs and making comments but not doing that to everyone else in the group." A White woman also shared her experience in a lab where the men were patronizing,

> Most of the guys were great, but there were some guys that were like, "Oh, here, let me do everything," and it's like, "I'm also in this class. I want to learn." Or I start doing stuff and they're like, "Oh, that's interesting. Oh, no, you're not doing it right."

Men also engaged in "dumbing" down content that women already understood. Some women described men talking to them as if they were not smart enough to understand the concepts. An Asian woman described her frustration with this experience, saying “In the group that I'm currently in, we haven't been able to figure things out yet really. And the fact that this dude also wastes our time over-explaining things that we already know, is frustrating to me.” Another Asian woman shared that she constantly experiences men in her classes using a “patronizing” tone and talking down to her:

> So that patronizing tone is something that I've experienced in other classes and actually in my [names course] group, which is my lab class right now. We are online, but I still experienced that a little bit with this one individual who's a male and the other two people -- it's me and another girl -- and the way he speaks to us as a little bit, like we don't know what he's talking about, he has to bring it down to our level or something like that and I've noticed that before with in other engineering courses and stuff like that.

A White woman also explained how men talk to her in engineering groups compared to women,

> In my [name omitted] group, when it's the guys that understand compared to the girls, the way that they explain things, it makes you feel really dumb when it's the guys explaining to the girls versus the girls explaining to the guys.

Besides speaking to women in patronizing ways, men also engaged in other subtle patronizing behaviors such as assigning women trivial secretarial tasks in group projects like taking notes or sending calendar invites. A White woman elaborated on her experience, “You don't even think about it most of the time, but when you think about it, if you're the only girl, you're probably taking the notes and sending out the calendar invites.” Another White woman further explained how men assign women into certain roles,

> When you're in a group with guys and they assume that you'll make meeting invite or you'll take the notes, and it's just assumed. And even if it's not assumed, usually, if you're the only girl, you end up in that role anyway just because that's what happens.

An Asian woman also described how when put into a recent group, as the only woman, the men, “gave me certain tasks that would be more stereotypical, like making the slide show and making it aesthetic.”

As a result of being treated in patronizing ways, women felt like they had to work harder to get any type of recognition or respect from men colleagues. A White woman explained, “I feel like there's a tendency in our major for women to have to prove themselves to the men, like they have to do better on an exam than a guy in order for the guy to respect the women.” Women also discussed feeling a need to constantly prove themselves to show they were smart enough to do the work since men often treated them like they were not. One Latina recounted her experiences on a team project and her feelings of having to prove herself. Although she began by saying that she didn’t feel intimidated by the three White men in her first-year design course, she quickly reversed course, saying

> Well, it was intimidating at first just because I felt like they wanted to dominate the conversation and the ideas that were brought up during our team meetings. I felt the need to prove myself because I was a woman with the other men in the room and so I didn't want them to have that idea of oh she's a woman, she doesn't know any better, but I think that's just maybe because you hear these stories where there aren't that many women in engineering especially. I felt like I had to prove myself, basically.

Racial Microaggressions

Regarding the intersection of both race and gender, all four Black women in my study discussed experiencing both racial and gendered microaggressions. Similar to White women who discussed being ignored, a woman who also identified as Black and Latina shared that White men and women have caused her problems in her groups because they do not believe that she is competent. She explained that she purposely sought out those with similar backgrounds because of this treatment. She also indicated that White women and men of all races engaged in this type of behavior toward her as well; these behaviors included, "people not listening to me, especially when it comes to men not listening to the women of the group."

Another Black woman discussed her experience in a group project in which the ideas she shared with her group were ignored by both men and women and then co-opted. She explained,

> We were working on food science and engineering. And every time I had an idea, they were like, "No, that's a terrible idea." But then five minutes later, someone else would say the same thing, they'd be like, "That's the greatest idea since sliced bread.

She also shared that she is never sure how someone is going to treat her because she is a Black woman, so she is careful to hide her identity when communicating with others by only using the first letter of her name,

> As a person, a woman of color, a Black woman, sometimes you don't know whether or not someone's going to treat you differently because of that. And so, for that reason, when I email people, I still have the [letter omitted], I don't have a picture of myself or other things like that because you don't know.

Another Black woman also explained that she is not sure whether it is bias or something else that causes people to react to her in certain ways in groups, so she took the opportunity to select groups in which she felt "safe". Yet another Black woman explained that she was used to being treated certain ways because “I've been Black all my life. It doesn't really bother me at all.” One of the two Black men I interviewed brought up how he navigated his race having had a conversation with his parents that others may find him intimidating. His parents instructed him to speak up first in groups to make others comfortable around him. The other Black man had transferred from a Historically Black College but made no mention of any racial issues he had experienced.

Only one Asian woman spoke about racial microaggressions. She discussed the “model minority myth” and how it bothered her that others assumed she is smart just because she is Asian,

> It’s more like small assumptions made just because of my social identity. Like, I would sometimes get the answer to something really quickly and I’d be helping some friends out and they’d be like, oh wow, you got that really quickly. Like you must be really smart or small comments like that. It’s kind of like I can’t tell sometimes whether it’s because that’s because they see me as smart as a person or if it’s like they’re assuming that I am because I’m Asian because there is that stereotype.

Women’s Acts of Resistance

Two women in my study described their attempts to speak up for themselves in situations with men. A White woman in Amar’s class shared how she dealt with men who engaged in demeaning behavior:

> I’m a pretty no bullshit person so I will call them out when they do that, so it doesn’t happen to me very often. But I’m just as rude back to them. If they’re going to be arrogant to me, I will just be like, ‘I actually know what I’m doing as well, thank you.’

Yet, the woman also shared how men reacted to her standing up for herself in these situations explaining, “They’re just like ‘Oh, you’re overreacting.’ They kind of gaslight me a little bit, like, ‘You’re just blowing this way out of proportion.’’’

An Asian woman also in Amar’s class was a transfer student and before the interview started had discussed with me her experience of having three older brothers. Later in the interview she explained how she handles situations with men in her major largely informed by her experience growing up with brothers, “I have three brothers, so for me, it's like I need to make sure that I have to put my voice in there and put what my position is on something.” She explained how this translated to her interactions with men in engineering,

> I personally set my standard out the first day. For example, last semester when we did [names course], I was in a group of like four guys and I think with that, I knew that I had to personally take charge the first day to make sure I'm not being put down just because I'm the only girl. But yeah, I think with that, for me, I personally just try to set the tone from day one and usually I do have a lot of questions and I ask them.

She went on to discuss the expectations she sets with men,

> But I think setting like, ‘Okay, yeah, we are at the same level,’ because we all are in the same class. But yeah, I think it's just like little things that you have to do to make sure it's all equal.

Both women in these situations were vocal and received different reactions when interacting with men in engineering. One experienced “gaslighting” where men made her feel like she was blowing things out of proportion. The other woman, informed by her personal experience growing up with brothers, made sure to assert her dominance in situations to prevent men from taking over. Unlike the first woman she did not encounter any negative treatment or comments from men.

Women's Social Identities and Self-Perceptions

Men peers, more than instructors in engineering, blatantly engaged in patriarchal behaviors in which they used their powers and privileges as men to ignore, exclude, and patronize women. Although it was not clear whether instructor behaviors were rooted in patriarchy, they were indeed rooted in superiority that made women feel inferior. As a result, women were less inclined to want to participate in and outside of the classroom and expressed feelings of low self-confidence and intimidation. In this way, the belief prominent in engineering culture that excludes women also contributes to women's development of social identities in engineering spaces and their self-perceptions of their abilities. Women's social identities as women in engineering appear to be shaped by interactions with both instructors and men peers in the classroom. Past negative interactions with both men peers and instructors contributed to women feeling bad about themselves, feelings of intimidation, and overall frustration. Women enter classrooms with these social identities that they have developed because of gendered and in some cases racial microaggressions. These overall feelings cause women to shut down and affects their participation in the engineering classroom.

Negative Self-Appraisal and Low Academic Self-Confidence

Women described issues of low self-confidence and harshly evaluated their own abilities. They expressed feeling intimidated in their classes, not wanting to ask "stupid" or "dumb" questions for fear of being judged by their peers. Women also described shutting down and not wanting to ask questions because they sensed that others knew more than them. They showed concern for being judged by their peers and causing them to be annoyed with their questions. Some women also shared that they did not want to interrupt the instructor during class, so they withheld any questions they had. A White woman shared,” It’s like, I feel sometimes, like it's kind of intimidating, because I feel like everyone else in that class is super smart and I have stupid questions.” Another White woman agreed, “It's just like you ask the instructor a question, and sometimes I hate asking questions because I just feel dumb, especially when people are further ahead on questions.”

A White woman described being laughed at in class for her questions and receiving snide remarks. Another White woman elaborated on her low participation as tied to her self-confidence,

> I think on a logical level, I know that that is not the case, that it's not embarrassing to ask questions and when I see questions in the chat that I do know the answer to, I don't think like, “Oh, that's a dumb question.” So, on an intellectual level, I know that, but just on an emotional level sometimes I'm just like, I don't know why, but it makes me nervous.

A Black woman explained why she is often reluctant to participate in class,

> I think a huge reason I used to not participate or why I didn't participate in the orgo [organic chemistry] classes, because you're in front of 500 people and you don't want to sound stupid, I think is a huge thing. And it's like, "Maybe someone else will ask this question," or you're like, "Maybe they'll explain it better," or you'll just be like, "I'll just ask them later." So, it's things like that where you don't want to be seen as embarrassed.

During classroom observations, many women showed doubt when asking or answering questions. My notes reveal that almost every woman who asked a question would use phrases like “Does that make sense?” “This may be dumb” “I’m not sure if this makes sense” or “Am I just thinking incorrectly?" Men on the other hand, never used any type of phrases that indicated they were unsure of themselves.

Women in the courses feared making mistakes in front of their peers and feared being perceived as incompetent, unintelligent, or inadequate. A White woman shared that she felt intimidated in her engineering classes because there are people that feel they are smarter than everyone else, making her less confident to participate in class. Women discussed how their feelings of inadequacy emerged from being surrounded by "super smart people." They describe feeling not intelligent enough and not wanting to approach people as a result. A White woman described her insecurities,

> I feel like sometimes I'm less intelligent than my peers. So, I can't approach them for homework help, I can't approach them for asking questions, and sometimes just can't even approach them just to talk them to them, because I feel like I'm not within their intelligence group.

For some women, feelings of low academic self-confidence made them experience "imposter phenomenon." A White woman elaborated on this,

> I really struggled with, I don't know, I guess it's the FOMO [Fear of Missing out] thing, I really did have that, or I'm not sure, like imposter syndrome, is that what it's called? That's the thing I think it's actually called, but I always would think, I don't know what I'm doing and everyone else does.

Some men discussed feelings of inadequacy in engineering but did not attribute those feelings to themselves. Rather they described how "others" may feel stupid when asking questions. A White man shared his general assessment, "So that kind of fear of, 'Oh, what if this is a stupid question?' Even though there are no stupid questions, people are still always scared, ‘What if this is one?’” A Black man also explained how “people” may feel scared to participate in class, “I think it's out of fear. People don't want to, I guess want that... This, I guess is what I think: I don't think people would want the attention.”

Student Perceptions of Classroom Climate and Inclusivity

Despite the negative experiences women consistently had with men in both group and classroom settings, the women in the study as well as men discussed how Roger and Amar engaged in inclusive pedagogical strategies and positive classroom behaviors that created a respectful, collegial, comfortable, and caring environment. Amar and Roger respected the students and treated them as equals making students feel that it was ok to make mistakes which encouraged their desire to participate. Amar and Roger’s behaviors which included positive reinforcement and validation through feedback fostered comfort in the classroom. The empathy they showed toward the students by also listening to their needs and making students feel that they had a role in shaping the course also contributed to the comfort they felt in the course. Roger’s humor also increased the students’ perceptions of a comfortable classroom climate. The comfort students felt in the classroom made them want to participate, attend, and engage in the courses. Students also felt that both instructors cared about them and their learning. This was made clear to the students in the way the instructors were flexible and expressed a desire for the students to understand the material.

Respect and Collegiality

Participants identified both Roger and Amar’s behaviors as contrasting to past experiences with instructors who were condescending and authoritative. A White woman in Amar’s course appreciated how he did not “shame” her for getting an answer wrong,

> I feel like when people ask questions in the chat, he almost always says like, "Oh, that's a good question," or something. He never breezes by them, I guess. He takes the time to answer questions. And then, I also feel like with the Zoom poll problems, he's never shame-y to people who put the wrong answer. It's always like, "Oh, I can see why people had put that," or something. Just like little things like that to not make you feel bad for messing up.

Another White woman, also in Amar's course, pointed out how he reacted to student questions, "He doesn't really put down people's questions, which I feel is sometimes the case in engineering." An Asian woman commented that she appreciated how Amar,

> Tries to get down to the student's level, I think, a little bit more and explain things to us in a way that we can understand as undergrads, because I feel like oftentimes professors will speak to you as if you already know what they have studied and stuff like that and where they're coming from in that aspect, so I appreciate that.

A White woman explained how Roger used a collegial approach because he, "talks to us on our level. It's not like, 'I'm a professor, you're a student.' It's like, 'All right, let's come together to get it so you guys can learn the material.'"

Some men in the study also recognized that instructors could be condescending, intimidating or use certain negative tones with students and contrasted this with Amar and Roger's approach of treating them as equals. A White man explained that Roger was "definitely on our side" and "Day to day talking to us, not in a way that makes him sound like a genius doctorate chemical engineer." A Black man in Roger's course appreciated how Roger was "not too intimidating with his teaching style." Another White man shared his assessments of Amar's classroom demeanor:

> I think tone is really important in the dynamic between a professor and his students, and I think Professor [name omitted] has a really good tone and is never ever condescending or anything like that, even though I'm sure some of the questions that we ask, seem like two plus two to him. So, I think that's really important and compared to some of the other professors I've had at [name of university omitted], who don't, I guess, have that understanding tone or create a learning environment, I think he does a really good job with that.

Women also pointed out how Roger and Amar welcomed mistakes which they viewed as the opposite of the attitudes of their engineering instructors, who typically made women feel bad for making mistakes. An Asian woman explained how Roger’s attitude compared to other engineering instructors’ egotistical behaviors,

> A lot of professors always try to seem as they are super polished. Like they know everything that's going on. But I feel like [name omitted], he keeps it really real. He doesn't try to make us think he knows things he doesn't. And he's always willing to double-check that the information is right. And he doesn't come off as - just confident, not like overconfident and unapproachable. And so, I think he just seems human, and it really helps you feel like you can talk to him about anything that you can get the help that you need. And so I do appreciate that.

A White woman said that the fact that Roger occasionally made mistakes in class made her feel better about her own mistakes,

> I would definitely say one of the things that he does is sometimes he makes mistakes of his own slides and he corrects them, like, he makes a joke of it and it makes it feel like it's okay to make mistakes in his class as long as you learn from them and correct them.

Because students' viewed engineering faculty as valuing perfection and rigor, women appreciated that Amar and Roger did not act like the material was easy but rather expressed honesty about the difficulty of the content. A Latina explained how Roger's honesty made her feel, "I would say it's definitely a lower stress environment or at least he makes it kind of come across that way where he gives personal anecdotes of like, "Yeah. When I first learned this, it didn't make any sense to me." A White woman shared how Amar was encouraging even if students did poorly on the exam,

> I'd say also with the exam, even just before grades came out and he was like, "It was a hard test. If you feel like you did bad, I promise it wasn't you." And even if you did bad. He's reassuring even if you score poorly on the exams.

Comfort

Women appreciated how both instructors created a comfortable environment through positive reinforcement, validation, empathy and humor which created an inclusive environment. The behaviors that Amar and Roger exhibited in class made women more inclined to attend class, participate, and engage in and outside the courses. A Latina described the "genuine" positive reinforcement in Roger's course,

> I think there's a lot of positive reinforcement when you ask questions. Because I think a lot of professors can be like, "Oh yeah, ask questions. They're good." But he really.. it seems genuine. He's like, "Oh, that was a really good question. Let me continue. Let's build off of that," and it feels very receptive in that way.

A White woman in ChE 101 explained how she was not afraid to ask questions in class because of the validation she received from Roger, "I never feel uncomfortable asking questions, because he's always like, "That's a great question." Or he always addresses it or he's like, 'You know what? I don't even have the answer to that'." Another White woman felt similarly in the way Roger responded to all questions,

> I also really like how he's never treated a question like it was a nuisance or like it wasn't wanted in the classroom. So, even if a question isn't really relevant, he'll still read through it and see what he can say about it, which I really, really enjoy.

A White woman in ChE 101 explained that she felt Roger welcomed questions rather than criticized them, "he doesn't, I don't know, criticize questions, even if they might seem like dumb questions, he doesn't frame it in that way." An Asian woman discussed how Roger's desire to make sure students' questions were answered made her feel,

> He just makes it very welcoming by making all the small talk and stuff too. He actually makes the class enjoyable and whenever anyone has questions, he actually answers them well, and then make sure, they understood it too. Instead of just answering and leaving at it. He follows up with them too.

Women also appreciated the way Amar responded to student questions. An Asian woman described how "the manner in which he responds to questions" was encouraging and "he always sounds very happy to be able to answer people's questions when they do come up and stuff like that and he explains it very thoroughly, which I appreciate." A Black woman discussed how Amar's responses to students in class was an inclusive practice she appreciated,

> He seems very careful with the words that he chooses, especially when he's answering questions of students, such that he never wants to make anyone feel uncomfortable or incompetent. So he does try to make a very inclusive environment and he's always willing to explain anything that needs clarification. And he always tries to start at a basic level by explaining things very minimally in the beginning, and then adding detail as we

> go on. So that way, once again, we feel comfortable with the material we're learning. I definitely believe that he understands that what we're learning is difficult in his eyes and that he wants to make sure that he's approaching it in a way that doesn't make us intimidated by the material. So I think in my opinion, he has done a really good job of creating an inclusive environment that welcomes questions, but also makes you think at the same time.

The same Black woman also talked about how the instructor used positive reinforcement to respond to questions during class, “he always makes sure to qualify his answers with like, ‘Oh, great question. I'm sure other people had that question.’ So that also just creates an inclusive environment to make you understand that you're not asking a ‘dumb’ question like people might think.”

Some men also described the instructors as receptive to students and their questions. A White man in Amar’s course explained how this made him feel,

> I think he's creating a very welcoming environment, one that welcomes any questions that anyone may have. He's always ready to answer those questions, like that. He never really pushes off questions until the end of class because usually that means that no one's ever going to answer the question.

A Black man commented on the environment Roger created which made it less intimidating, “So I think he creates a pretty welcoming environment. That's not too, or I guess students aren't really too, I guess, intimidated or afraid to ask questions.”

Women described how they felt Roger and Amar made them feel validated by encouraging their feedback which made them feel like they had an important role in shaping the course. Students also felt that Amar and Roger listened to them and their needs (empathy). A

White woman in Roger's course shared how the comfort of the environment made her feel like she could speak up, "I would say it's a very comfortable environment. It also makes you feel like you have input into the class, I guess. It's a lot easier to speak up about things." Students indicated that it was important for them to feel that their voices were valued in the decision making of the course. A White woman described how Roger soliciting feedback made her feel like she had a "say",

> I especially appreciate when he's asking us for feedback throughout the course, or "Hey, does this seem like a good idea?" Or "What do you guys think?" I really enjoy that. It makes it feel like we have a say in that's going on and we always know what's going on in the class.

In Roger's course a White woman explained that she felt he listened to student opinions,

> He's also very willing to work with us. So he asks our opinion on a lot of things and he'll do a lot of polls and get like, ask us how we want things to be due and how we like the class, how it's going, which is like really nice that he listens to our opinion.

A White woman in Amar's class shared that she felt he was responsive to student feedback,

> He's really interactive in both the sense that we are contributing during the class, we're doing Zoom polls and asking questions, but also he's very responsive to our feedback. So like I know during midterm feedback, he would address at the beginning of class every day or try to fix things, make it easier with us.

Roger's incorporation of humor during lectures was appreciated by students and added to the comfort in the classroom. A White woman discussed how Roger was "always making dad jokes. They're kind of dumb, but it's nice. It kind of keeps the tone light." Another White woman explained the connection between the instructor's humor and the comfort felt in class, "And by kind of being more lax and I don't know, he's joking around and things like that. I think it makes us all a bit more comfortable.” An Asian woman described the way he presented himself through humor which made the environment feel more welcoming,

> he also just smiles a lot when he has his camera on. I feel like that also just makes it more welcoming. And he also makes the joke all the time about how exciting [ChE 101] is, which isn't, but it kind of makes you think it is because he says it all the time. So you want to focus on what he's saying too.

A White woman explained that she felt Roger’s jokes made the environment more open,

> I definitely think he has a really honest and open, interpretation to the classroom, and the way that he kind of jokes around with the class and is always making sure that everything that's going on through his mind is being spoken and outwardly expressed, kind of helps with that.

Another Asian woman also shared how she appreciated Roger’s humor which she felt created a positive environment,

> I like how laid-back the lectures feel. Compared to some of my other engineering classes, I feel like I'm writing notes the entire time. He's always cracking jokes and just making it seem more like a conversation, rather than an exhausting lecture, which I like a lot.

Some men also commented on the use of humor in the course as well. A Black man discussed how he enjoyed Roger’s humor, “We used to just joke around a lot. So it makes it a little more fun than I think just... than a professor, just lecturing and just talking about the content.”

The comfort women felt in the courses made them want to participate, attend, and engage in and outside of class. A White woman shared how the positive treatment she received from

Roger made her comfortable in the classroom making her want to show up to class regularly, "I don't feel like he's going to judge us. He wants us to learn and wants us to be comfortable with him, so I think I've really appreciated the environment he's created. I look forward to coming to class every day." Another White woman shared how the environment Roger created made her feel comfortable participating in class discussions, "I would say that Professor [name omitted] really tries to create a very relaxed environment, like a comfortable environment where we're all able to speak freely when we need to and ask questions when we need to." An Asian woman also talked about how Roger "will stop to make sure everyone understands. If not, then he'll take questions, make sure that people are understanding."

Because of his attentiveness to the students, an Asian woman in Amar's course felt more comfortable participating, "I don't know but, for me, I felt super comfortable asking questions in the chat box and then he always notices and then will just answer me right away." Women participants also felt that Roger and Amar's desire to include them in decision making processes in the course made them want to ask questions,

> One thing he does is he always asks for input. I think that's really helpful. He's always asking things that he can do better and things that we're struggling with. And he definitely makes sure that we know that we can ask questions and stuff. He's like, "If you have any questions, make sure to ask." It makes you feel really open.

A White woman in ChE 201 explained how the comfort she felt made her more engaged in the course,

> So I think people are just really keeping up with what he's saying and that kind of makes people more inclined to participate, because I know if I blanked out during a lecture slide,

> I would never participate. But I feel like he just keeps personally very engaged and I feel very comfortable in his class.

Women were also engaged in the courses by attending office hours for both Amar and Roger. A White woman explained how the ChE 101 environment made her feel comfortable engaging with Roger outside of the classroom by going to his office hours.

> I would say he creates a pretty welcoming environment. I'm more reserved sometimes. Especially when it comes to professors, it can be intimidating in a harder program, but I always feel very comfortable going to his office hours or asking questions when necessary, which is something I've noticed particularly about him compared to my other professors.

Some men in the study also discussed how Roger and Amar’s responses to questions created an environment where people felt engaged and comfortable. A White man in Amar’s course elaborated,

> So I can't really explain how, but he has a really good way of like getting people to want to ask questions, getting people to be engaged with what he's teaching and making them want to. Some classes people are very hesitant to ask any questions during the lecture.

Feeling Cared For

Women discussed how they felt the instructors were “genuinely caring” about the students and their learning. A White woman in Roger’s course discussed how the instructor showed care, “So the fact that he will elaborate for the sake of just helping one student’s experience really shows that he cares about not just the overall class as a whole, but he cares about each individual student succeeding.” Another White woman similarly shared that she felt Roger created a classroom community as a result of the care he showed for the students, “I think that he definitely makes it feel like a smaller group than it is. He tries to really make a personal connection with you. And I think you can tell that he really cares about how we are doing in the class and how we're feeling about it." An Asian woman also shared that she felt Roger cared about student learning overall,

> He just seems super excited to teach, and I think that's really great because sometimes if a professor doesn't seem passionate about what they're doing, it's hard to really learn, like if they don't really care, then why should I care? And so I think it's just really nice to have a professor that really genuinely cares, and he seems like he just wants us to learn and doesn't really care about the grades so much because if he was looking for a specific grade distribution or something like that, then he wouldn't have the class set up as it is. I mean I'm sure he knows that class setup as it is, he'll probably have high averages, but he doesn't really care about that. What he wants is for us to just learn the material, so I actually really appreciate that.

The notion that Amar cared about student learning also came up in discussion with a White woman,

> It does feel like he cares a little bit more than other professors I've had. Like last semester, I felt like, okay, they really just don't care if I'm learning this at all, they are here to teach the class and then go to do their research, but I feel like he's not like that.

Another White woman further elaborated on how she appreciated Amar garnered feedback from the students to determine when to give them an exam,

> I think he really cares about what we say that he took the time to poll us and asked about what days worked best for us. He gives us that little break during class, understands that

> we need a break from that long of the class, so I really appreciate that. I think he really genuinely cares that we are understanding the material.

Women participants also expressed gratitude for the instructors' flexibility and understanding that they were in other tough courses which showed them they cared. A White woman explained how Roger was empathetic after hearing about an exam the students had just taken in another engineering course,

> And he genuinely cares, like today he was like, nobody's really talking. And then someone said that we got our [name of course] quiz results and he was like, "Oh, okay. I get it." In any other class we wouldn't mention, "Oh, we had a [name of course] quiz."

Sometimes Roger would also poll the students to determine if he should scale back on the quizzes depending on their workload in other courses. The students appeared to appreciate this gesture.

A White woman also expressed her gratitude for the way Amar responded to students, his flexibility, and small gesture of writing "good morning" on his slides that made her feel he cared about students,

> So he'll restate questions that are asked in the chat so people watching the recording can still hear it and learn from the question and also just being flexible about conflicts during the lecture. So you can have a makeup ICP time, I think that's something that shows just he fundamentally cares about every student having the opportunity to succeed. And also, this is the tiniest thing ever, but every morning he hand writes good morning on the first slide. And it's like a cute thing that makes me realize like, "Oh, this is his morning too, we're all here in this weird classroom together."

Roger and Amar's positive interactions with students, such as through office hours, also appeared to show elements of care. A White woman shared her positive interactions with Amar during office hours,

> He just is a very, I don't know how to describe it, I'm bad at describing personalities, but very approachable, very like, "Hey, I'm going to help you out." Like "how can I help you out" sort of attitude.

Another White woman explained that Amar answered her "silly" questions and was interested in hearing how she was doing in the course,

> I felt some of my questions were very broad and a little silly, but, yeah, it's kind of what he does in class, he just answered them all, very straightforward. Then he also asked me, "Oh, how are you doing in the class? What's the general sentiment? Is there anything we could be doing better as a teaching staff?" I was like, "Oh, that's really nice to hear, too." He's a nice dude.

A White woman shared that Roger was similarly helpful and friendly when she went to his office hours,

> I went to his office hours at one point just to ask a random question about some unit operation that I like, it came to my mind when we were doing that unit and he, it didn't really have anything to do with our quizzes or anything, but he didn't care. He was happy to talk it out with me and he was just really helpful and friendly.

An Asian woman also appreciated how respectful and helpful Roger was not only about course content but about professional career advice,

> I've been to his office hours a couple of times, and whenever I'm there, he is very respectful. He tries to help wherever he can, and he gives great advice on things outside

of class, such as, how do you find research over the summer? Where are good places to look for internships if you're still looking?

Some men also described these instructors as caring. One Black man shared that he felt Amar “actually cares” which was based on a personal interaction he had with Amar,

> I've talked to him about my standing in the class, I wanted to make sure I didn't have to drop it or anything because I got one more semester after this, so I don't have time to be retaking classes and stuff, so I wanted to make sure I was in a good place, and then he inspired me that I could still pass the class if I just showed improvement. And I showed improvement the second test. And then he actually emailed me afterwards, telling me “Congratulations" on it. I felt good about that email. I can tell he's not a mean-spirited person, like I've experienced teachers who are mean-spirited or just don't care. I can tell he actually cares.

A White man, also in ChE 201, shared how he also felt Amar cared about students,

> I think first off, he's a great person, I think is a great instructor, and I think that he's really nice and really cares about his students. And I think the environment that he creates is really welcoming. I think that he really fosters student feedback and discussion in class. Every time a question is asked in class, he's really understanding and does his best to give a comprehensive answer.

Integration of Diversity, Equity, and Inclusion

Roger’s attempts to integrate aspects of diversity, equity and inclusion into the curriculum was widely welcomed by women students in engineering and less appreciated by the men in the course. At least half of the sample of women enjoyed and agreed these topics were important to consider in engineering while some men preferred a color-blind approach in engineering that focused on concepts and problems. Roger led two discussions in class focused on DE&I, one focused on the effects of dams on communities and another on implicit bias. He also wove DE&I into the homework problems pushing students to think about the effects of engineering on marginalized populations. Women's positive responses were evident during one of Roger's class sessions in which students engaged in a conversation about the impact of dams on communities. A woman of color spoke up to share her happiness that the class was discussing the topic because she often did not get opportunities to discuss these types of issues in engineering. An Asian woman also explained that she enjoyed the DE&I conversation during class,

> The DEI, I definitely remember having a really good conversation with the students. It was smaller and people had really great input. So I really liked that; DEI usually isn't brought up in engineering classes. So I thought that was pretty cool.

A Latina in the course who also had some indigenous heritage similarly appreciated how the discussion on dams centered the effects dams can have on a marginalized community, something she recognized as unusual in engineering,

> I think I feel more comfortable in this class than some, and like I said, I've been very lucky to have some really cool professors at U of M even within engineering. I have indigenous heritage, and this is the first class I've ever heard anything about indigenous people mentioned and how he talked about when we did the DEI thing, how a lot of indigenous people are way more frequently displaced and other minority communities of color are more frequently displaced for these projects. And it's not something that people take into consideration very often. That made me feel more comfortable because I was like, "Oh, okay. We're actually acknowledging those things."

She also felt that as an engineer it was important for her to learn about these topics,

> I really enjoyed when he did the DEI type problems, because it felt like, one, he was bringing attention to a topic that's obviously really important. And two, it's just easier to connect to your real-life situations and what we're going to have to deal with as engineers.

Men Peers' Responses to Diversity, Equity, and Inclusion

Although most students appreciated the integration of DE&I into the course, one White man I interviewed, who identified as a devout Christian, appeared to strongly believe in engineering's objectivity and neutrality. He discussed being frustrated with the College of Engineering for telling him "what to think and care about" and felt that he should be receiving strictly an engineering education focused on engineering concepts and nothing else. He elaborated, "Sometimes it feels like the College of Engineering is implementing their values upon me, which can go directly contrary to what I am to value."

Most Men also demonstrated a color-blind approach, disregarding social identities and viewing everyone as an engineer. This approach of not recognizing differences and viewing everyone as engineers is an assumption of neutrality that is common in engineering culture and that contributes to the argument that social justice issues do not have a place within engineering. This color-blind approach recalls Amar's statement in one of my interviews that he believed everyone who puts in the work is a part of the engineering community. A White man explained his belief that he had an *engineering* identity and that *social* identities were inconsequential to him and in the college of engineering as well:

> I will have a conversation with you. And there's nothing, there's no reservation. There's no something that like a social identity that could be lingering in my head that I have to,

> oh, or then that becomes some kind of conversation piece. Especially in the classrooms it's just, we're all engineers, we get to be in this family that consists of engineers, and that is our foundation for a conversation. Foundation for our friendships, relationships.

Another White man similarly stated that everyone was equal and that social identities did not make a difference, especially at his university. He explained that the university

> It's really tough to get into and it's fairly diverse. So you see these people, even if they're very different social identities from you, but you know they must have put in some sort of major effort to get here, to be here, particularly in engineering you have more so than some of the other schools that might have a stigma against them.

Classroom Sense of Belonging

Besides participants appreciating the positive classroom climate Amar and Roger cultivated, they also felt that they were in community with their classmates in the courses. Students' classroom sense of belonging emerged through virtual and group interactions. In my study, I utilized Strayhorn's (2018) definition of sense of belonging which he discusses relates to how students perceive their social support, feel connected, cared about, accepted, respected, and valued by the group. The comfort that women felt, the care that they felt, and the inclusiveness of the classrooms made women feel connected to their classroom community. This was evident in the way the instructors facilitated the course and offered opportunities for student interaction. But it was also evident in the way that the students were able to connect with other students who they felt accepted and respected them, particularly in Amar's course where many students were in groups with friends who they felt cared about them and where they felt socially supported.

In Roger's course, the students developed a sense of belonging through their active classroom chat where students would ask, and answer questions related to the course. Women felt more comfortable participating in class and felt socially supported because they were able to use the chat function in class and felt that their peers were always willing to help when a question was asked. This helped mediate women's feelings of intimidation, self-consciousness, and insecurities that they brought with them, as part of their social identities, into the classroom. Amar's students engaged in group work and felt comfortable, cared for, and respected by their teammates. Women sought out teammates who were non-judgmental and supportive which created a more comfortable group environment that felt "safe". For some, this included being in groups with other women of the same gender while Black women in particular sought groups of not only the same gender but of a similar racial/ethnic background.

ChE 101: Virtual Peer Interactions

In ChE 101, students described a comfortable classroom community based on an active classroom chat function. Women felt that the in-class chat function was engaging, made them less intimidated, and made them more comfortable in class. A White woman described the activity that occurred in the chat during class,

> The chat's active. One time I had to leave to go to the bathroom, and I came back and there was like 10 or 12 chat messages. I was like, "Holy cow." Sometimes, it's just funny little messages responding to Professor [name omitted], or it's actually questions about what's going on in lecture, or some kids even answer people's question. If Professor [name omitted] is in the middle of something, they can be like, "Oh, no, here," if it's a quick question. So, yeah, everyone seems pretty active and engaged.

The in-class chat allowed students to interact with each other by answering each other's questions or sharing comments. A White woman discussed how the chat was used in class compared to other engineering classes, "I see a lot more people asking questions or answering questions than I do in the other Chem E classes that we're all in." Another White woman shared how she appreciated being able to speak with her peers through the chat, "it's nice to just have other people clear up your concerns or questions at once, without disrupting anything that's going on."

The chat was at times used to send words of support or encouragement to other students in class. During an in-class discussion about dams, I observed a man who shared that he was from an area that had flooded due to a dam breakage. Many students offered kind words and support when he shared this in the chat. Women felt that using the chat was less intimidating and made them feel more comfortable in the course. The chat function, especially for women, appeared to be a tool that helped them overcome issues of self-consciousness and insecurity that plagued them as women engineers. An Asian woman explained why she preferred using the chat,

> I would tend to use the chat just because you're not interrupting the professor speaking necessarily. And you're not getting all the attention on you cause not everyone looks at the chat necessarily. So it's a more less stressful way of asking a question.

Another Asian woman liked the ability to send a message through the chat to not interrupt the class,

> This might just be a me thing, but it's also sometimes if you're talking, I feel like I'm interrupting the lecture. Again, that might just be a me-overthinking kind of thing, but sometimes the chat's easier because you know that you have the rest of the class or the GSIs that might be able to just answer it, and Professor [name omitted] doesn't have to stop lecturing to answer it.

A White woman also discussed the notion of not interrupting which made her more comfortable using the chat,

> I feel more comfortable asking questions because I don't have to interrupt the instructor while they're teaching, because I have the chat option, in-person I'd have to raise my hand, they'd have to fully stop their lecture to answer my question, which is a lot more intimidating. And it feels like I'm stopping their progress in the class.

A Black woman expressed her appreciation for how the chat gave her time to compose her questions,

> I know I'm more comfortable using the chat because sometimes it takes me a while to get my thoughts together. So with the chat I can draft it and then see that it makes sense. Make sure that, the question that I'm asking hasn't already been answered and that it’s a good question, and then I can send it versus just talking on the fly-it can be a little bit overwhelming sometimes.

Some women also described preferring a low stress option to participate compared to raising their hand during an in-person class. A White woman elaborated on her comfort using the chat compared to participating in an in-person class,

> For me, this is the only class I've ever used the chat in, to ask a question. And I think that it's actually easier for me to ask a question in the chat than it might be to raise my hand and ask a question in a lecture hall full of people.

Another White woman expressed similar sentiments when comparing using the chat versus participating in-person,

> I feel comfortable typing in the chat and asking questions. I would never ever raise my hand in a class of 70 people to ask a question, but I feel more comfortable typing in a question in the chat.

Another White woman indicated that the responses in the chat seemed more respectful than when interacting in person, saying, “I do notice that in the chat, if I have a question, if another student's answering it, it seems a lot more respectful than kind of twinged with a ‘You don't get this’ kind of vibe.”

Men also understood how using the chat function in class could be less intimidating. A White man described how others may feel,

> I definitely find that people can use the chat because they don't have to speak, they don't have to kind of even get a little bit vulnerable, if that makes sense. They can just kind of throw the question out there and they know someone will get to it. And it's just that quick kind of interaction, and that's it.

An Asian woman summed up how the chat function in class helped her feel more connected to her peers in the course,

> I think I know a lot of my classmates more now, based on whatever they've texted in chats, whatever we've talked about in the GroupMes to the point where I'm sure if someone were to introduce themselves in person I'll be like, "Oh, Hey, I know you from whatever.

The connectedness that women felt in the course, the social support, and the respect that they felt from their classmates created a sense of community that contributed to their sense of belonging in the classroom.

ChE 201: Group Interactions

Both men and women in the study shared that they preferred being in a group with people they had worked with before. Women indicated that in their groups they felt comfortable, mutually supported, accepted, and respected. A Black woman shared, “So I think overall, we're more comfortable with one another and understanding our limits and what we actually understood and didn't understand rather than constantly having this pressure to contribute equally all the time, every week, every class.” An Asian woman also felt comfortable in her group since she had worked with the same people before,

> The reason why I stuck with this group is because I like working with them and stuff like that. So compared to other groups, I'd say we've gotten more comfortable with each other. There have just been experiences in group projects where people are not really contributing and so I don't feel like that's the case with this group, which is good.

Women also described how being among friends allowed them to be vulnerable, make mistakes, ask “stupid” questions, and not be judged. A White woman discussed how she felt accepted by her peers and that it was ‘ok’ to make mistakes in her group,

> So I feel as though I can really trust if they're telling me, "No, the way you're doing this, I think it's a good idea, but it's wrong." I believe them and I'm not defensive. I'm like, "Oh, okay, can you explain to me how to do it.

Another White woman discussed how she felt she could ask “dumb” questions, “I feel a lot more comfortable asking other students questions, like stupid stuff like, ‘Oh, what the heck is the n?’ rather than asking somebody important.” Another White woman explained that it is an “easier forum to ask the stupid questions, quote-unquote. I feel so much better about asking really basic questions to my [name omitted] group.” A White woman expressed how she felt her group was accepting and non-judgmental compared to other groups, “I don't feel judged by my group members, which I think is a good thing and that's not always true in engineering groups, so I feel thankful for that.” Another White woman explained how she also felt accepted and not judged in her group,

> I feel like It's nice to bounce ideas off of somebody that I can relate to on a personal level without having to feel judgement. Like if I do something wrong, I'm not going to feel as like harshly judged if it's someone that I would call my friend versus like, if I were in a room with a random stranger, and I got something wrong, I'd probably be mortified. I would feel incompetent, and I probably wouldn't really want to participate as much or as vocally at least.

Additional women also appreciated the mutual support they received from their groups sometimes asking each other for help and using each other as resources in the course. A White woman explained how this support materialized in her group,

> I feel like in my group, it's the understanding that we bring for each other. It's okay if we are not always on brain-wise. It's okay to have days where you're not thinking as well, or if you have a crazy week and you have to leave early.

An Asian woman shared how her group supported one another, "I like my group in general, I think we get along really well and we're super nice about explaining things to one another, making sure everyone's on the same page." Another White woman described her content with the Instructor and TAs letting the students pick groups and shared how the women in her group used each other as resources,

> I appreciate the fact that they let us pick our groups, because then those people are also people that I'll talk to after classes like, "How is homework going?" Because we'll be like, "Oh, this is like the ICP we did on Tuesday." So I think having that consistency helps with other aspects of the course too.

A White man and three Asian men also described feeling comfortable with their group and appreciated being able to pick friends in their groups. They felt they could bounce ideas off each other, engage in collaboration, and expect group members to make equitable contributions. The White man explained why he enjoyed working with people he had worked with before and felt "close" to his group members,

> I think, it's been beneficial to work with the same group, because you get more comfortable with those people. You learn how the other people learn, how your peers learn, and you start working a little bit more efficiently as a group. And just, I mean, you become closer, you start to see deeper and deeper sides of people.

Similarly, an Asian man also described working with a group he had worked with in other courses as a positive experience.

> So, I think, in general, the option to pick the groups helped a lot because it was a lot more consistency and ease of working with people that you know. I also picked a group that I'd worked with multiple times in previous classes, so it all went pretty well. In general, from my participation in my group, I think 95% of the time, all four of us were there.

A Latino who had worked with his group in a few other classes really enjoyed working with them compared to random people,

> I think working with the same group over and over does definitely helps. I think working with friends, maybe not all friends, but especially if you've learned to work together as friends, then it really makes things a lot smoother because you know what to expect from each other and know everyone's strengths. Just some random teammate, you have no clue if they'll help or not.

Women in Amar's course felt socially supported, accepted, and respected in their groups which made them comfortable and allowed them to be vulnerable with each other. Although these findings show that women developed a sense of belonging in groups through the community they created in their self-selected groups, it is not clear weather self-selected groups were the main impetus for their development of a sense of belonging.

Sexism and Gendered Racism in Engineering Groups

Women also discussed that being in groups with men was intimidating and that they had more positive experiences being in groups with other women. Women shared that they felt more comfortable with other women rather than men and felt more comfortable speaking up with other women. A White woman in ChE 201 described why she had chosen an all-female group,

> I was in a group with one other girl and it was like three other guys and definitely got talked over like 90% of the time, from the guys. And it's just kind of like a little de-motivating, my next group, when we were able to choose our partners definitely chose an all-female group.

Another White woman in the course also responded to how having a group with all women made things easier for her, “I'd say it was nice. I already had all the girls' numbers that I'm in a group with, and we text all the time. It's not just about ICPs [In-class Problems]. So it's just very fluid. Any time I have a question about the class at all, they're responsive.”

A White woman in ChE 101 shared how she felt being in a group with all women was a positive experience,

> Last semester when we were taking [course name omitted], which was a prereq for this class, we often got split up into breakout rooms in that class and they kept the same breakout rooms throughout the entire semester. And my breakout room was me and three other girls. And so being in a breakout room with guys is very normal, but being in a bigger room with just girls, I think all of us felt way more comfortable to speak up and to start the conversation.

Black women in the study appreciated the opportunity to choose group members who shared both their gender and their race. A Black Latinx woman in ChE 201 shared that she felt more comfortable with women of the same race,

> I specifically chose my group based on my identity. I identify as a Black or African American woman who is also Latinx. And a lot of my group members are also of those identities. So I specifically chose that based on past experiences of people of other race identities not listening to me, as I mentioned, as negative experiences before. So I think that having people with similar identities to me allowed me to have a more positive experience just in terms of listening to one another and being able to contribute equally within the group.

She then described how others that do not share her social identities have treated her poorly,

> Navigating other settings, such as another class I'm in right now, where our groups are assigned, has caused a more negative experience just because I'm not able to work with people with the same or similar social identities or that I know acknowledged the differences between social identities and are comfortable with working with different identities such as group members not thinking I'm competent enough or different things like that. So it's been more negative. It's more negative when I'm not able to carefully choose a group or have more options and it's more positive when I'm able to choose them myself.

A Black woman in ChE 201 described her desire to choose her own group as an attempt to feel safe,

> I basically created or asked people to be in a group who I felt safe with because I didn't want to run the risk of it not being that way. I think that adds to Professor [name omitted] being accommodating in even letting us choose our groups.

She further explained how factors around her social identities contributed to her desire to choose her own groups,

> Anytime I get an opportunity to create the group that I'm working with or the people that I have to work with, I'm going to just because I don't want to have to try to pinpoint why people aren't working or talking because they're shy, because they don't know me, because of any underlying biases. I just don't have time to figure that out so any route that I can take to avoid that, I do.

The negative experiences that these Black women encountered because of their race influenced how they navigated groups.

Conclusion

My analysis has identified how women's experiences in the engineering classroom are shaped by past experiences with instructors and peers that reflects an exclusionary, sexist, and racist culture. Women perceived Roger and Amar's courses to be different in the ways they opposed engineering culture through their instruction. Roger and Amar were respectful and collegial toward their students encouraging student participation and creating an environment where women did not fear being judged and felt it was acceptable to make mistakes. Roger incorporated aspects of DE&I that were valued mostly by the women students in the classroom who had never been exposed to those types of conversations in other engineering classes and felt they were important. Roger and Amar also created a comfortable environment in the ways they responded to students answers and questions through positive reinforcement and validation. They also created a comfortable environment in the way they listened to the needs of the students by showing empathy and made adjustment to the course. Roger also incorporated aspects of humor to make students comfortable in the environment. According to women and some men, both instructors showed that they cared about the students and their learning. Women appreciated how the instructors consistently asked for and felt that their input was valued and taken into consideration (also empathy).

The communities that the students created through virtual interactions in Roger's course and the groups that students were allowed to self-select into in Amar's course helped students develop a sense of belonging in the courses. They felt supported by their peers and indicated that they were more engaged and also enjoyed the course more because of these connections. Overall, what Roger and Amar did in their classrooms, their inclusive instruction, made a difference for women's experiences in the classroom providing them with perceptions of an inclusive classroom climate, feeling of classroom inclusivity, and a classroom sense of belonging.

Chapter 7 Qualitative Findings of Confidence, Capability, and Desire to Remain in the Field

Capability and Confidence in Engineering/Desire to Remain in the Field

I have used Bandura's definition of self-efficacy - the belief in one's ability to complete a task - to inform my study. The Engineering Self-Efficacy measure (Concannon & Barrow, 2009) I used in my survey measured students' perception of excelling, succeeding, and completing engineering coursework and the major. To ensure I was using terms familiar to undergraduate students I did not use the term self-efficacy in asking group interview questions; instead, I asked students whether they felt more or less capable in succeeding in their engineering courses and the chemical engineering major. Although capability is a similar construct to self-efficacy, it is not entirely synonymous; accordingly, in this chapter I discuss participants' sense of their capability and confidence to distinguish between the measures used in the survey and how students described their belief in their abilities to succeed in engineering. The instructors in this study sought to enhance students' sense of capability which therefore created an inclusive classroom environment.

Table 7.1 presents the key findings related to the socioemotional outcomes of engineering capability, confidence, and desire to remain in the field of engineering. These findings demonstrate the connection between instruction and these socioemotional outcomes.

Table 7.1

Key Findings: Instruction and Engineering Capability, Confidence, and Desire to Remain in the Field

	Key Findings
Focal Courses: Instructor's Contribution to	• **Instructor pedagogy** such as attention to clear instruction, open and honest discussion about the challenges of the work and applicability of the examples in class made women feel more

Capability and Confidence	capable and confident that they could be successful in engineering courses and in the field of engineering. • Roger's **grading and feedback** using regular quizzes and immediate feedback made women feel that they could be capable in engineering and gave them confidence that they were learning in the course. • Women had **confidence in learning in Roger's course** which also contributed to them feeling like they could be successful in future engineering courses. • **Group problem-solving in Amar's course** involved students feeling solidarity with one another but did not connect the experience to their learning.
Focal Courses: Limits of Inclusive Teaching	• A subset of four students felt **ambivalence in Amar's course** because they felt the course was challenging and they had experienced the same feelings in other engineering courses they had taken. • Another subset of students already felt highly capable and although they appreciated Roger and Amar's pedagogical choices, they felt that as a result of the instruction there was **no change in confidence or capability** in engineering • A subset of students felt **a lack of capability and confidence in Amar's course** but attributed these feelings to the content because they felt it was challenging and difficult
Focal Courses: Desire to Remain in Chemical Engineering	• Women discussed the **content of the courses, Roger's connection of concepts to the real world, and feeling that they were learning** as contributing to their desire to remain in chemical engineering. • Three students who were all very confident in their ability to do the work indicated that they had gained **clarity on the desire to remain in the field in chemical engineering** and were no longer interested in pursuing chemical engineering.

Overall, students in the study described several ways the instructors contributed to their beliefs in their capabilities and their confidence to complete coursework and to pursue engineering as a field. Specifically, both men and women in the study reported that the pedagogical strategies that instructors engaged in, such as their methods of explaining and breaking down information and using applicable examples increased both their capability and confidence to be successful in the engineering major. Men and women reported that the grading and immediate feedback they received in Roger's course due to the quiz format, contributed to their capability and confidence because they mitigated negative experiences they had in other engineering instructors' courses. Although many students reported high levels of capability after taking the courses, some students did not report experiencing increased levels of capability. In Amar's course, some students shared that they did not have increased feelings of capability, one woman citing the online format as a contributing factor while across groups, others explained that they were near graduation and were "used to" the rigor of chemical engineering courses. Some students in both courses also shared that they had the same high levels of capability as in other engineering courses.

More than half of the women interviewed indicated that both courses provided them with applicable skills to prepare them for working in the field of chemical engineering, which increased their confidence and their desire to remain in the field of chemical engineering. Also, a Black woman and Asian men in Amar's course indicated that even though they felt they had high levels of capability and confidence, they also felt a lack of a desire to remain in the field of chemical engineering. Therefore, it is important to note that my analysis reveals that for students in this study, an increased sense that they could succeed in a chemical engineering degree did not equate to a desire to remain in the field because not all students who reported an increased sense of capability planned to remain in chemical engineering.

Instruction's Contribution to Capability and Confidence

Both women and men attributed increased levels of capability to pedagogical choices made by the instructors in these courses, their teaching styles, and even the curriculum. Particularly for Roger's course, both women and men appreciated the structure of the course and felt that it contributed to an enhanced sense of their ability to succeed in the major. More than half of the students reported that the structure of Roger's course allowed them to continuously improve their grades which made them feel they were performing well academically thus contributing to their feelings that they could succeed not only in the course but future engineering courses.

Instructor Pedagogy

Women felt that both Roger and Amar's pedagogical choices and styles in the class increased their confidence and feelings of capability to accomplish the work. Some women described how Roger's "open" teaching style contributed to success in the course. A White woman elaborated on how his honesty about the difficulty of the material gave her confidence,

> I like that he's honest about how well he understands the information. If you think something's hard, he'll tell us that he thinks it's hard, which makes me feel better if I don't understand what's happening. And that gives me more motivation, like, okay, I can learn it.

Another White woman discussed how her positive experience with Roger's teaching made her understand that an instructor's teaching style contributes to her feelings of inadequacy or her sense that she can succeed in a course,

> I also think that the fact that we have a cohort and we all are taking the same two classes at the same time, this class -- which everyone loves -- and another class -- which people have way more unfavorable opinions about -- has proved to me that a lot of the times how well I do in a class isn't necessarily completely my fault, because I'm doing a lot better in the class that I am enjoying more and have a better professor. And so it's just told me that I have the ability to basically, succeed if I just have to apply it. And it has a lot to do with the professors and not so much to do with my own inadequacy.

Amar's teaching style also had positive effects on some of the women in his class. A White woman stated that she felt he was "overly" clear when he was explaining concepts which helped her confidence in her ability to do well in the course. Another White woman also described how Amar's way of teaching improved her sense that she could succeed in the chemical engineering major,

> I would say I felt a lot more capable of succeeding, and I've described Professor [name omitted] as like, a YouTube crash course instructor; like he makes things seem like so overly clear that you're like, "Oh my gosh, I'm the smartest person ever. This class makes so much sense. I finally don't feel very distant from what I'm learning."

She then linked this sense of capability to her sense that she had chosen a degree program in which she could succeed,

> So I think that made me feel just more confident and being in the right major, knowing that I know what's going on for my degree requirements. So I think that definitely made me feel better about it.

An Asian woman in Amar's class also commented on the clarity of his explanations of the concepts and the ease she felt in understanding those concepts,

> it's probably just because of the nature of this course or, probably, Professor [Amar] did a good job. I found myself having a really easy time understanding the material of this class, better than other Chem E classes

Students in Roger's course similarly observed how the quality of the professor's explanations and examples contributed to their sense that they understood the course content and could do the work. An Asian woman reflected on Roger's clear explanations, which increased her sense of personal capability,

> I think I feel more capable in this class. I think it's because everything is described so clearly that I feel like I'm understanding it well enough to do problems on my own without even consulting other resources. Whereas in other classes, some engineering classes, the material isn't explained as well. So then when I get to problems, I don't know, like I'm stuck for a long time and I feel like I'm not really capable, but it might just be that I didn't get the full education.

Another Asian woman appreciated the applicability of Roger’s examples, and how they increased both her understanding of the concepts and her assessment of her capability, “I think I do feel more capable. I think a lot of the real-life applications problems that we've been given; just how everything seemed more tangible and applicable to what I've learned already.” A third Asian woman contrasted her experiences in Roger’s course with a negative experience she had in another engineering course and explained that “this class makes me feel better than any other classes have.” She continued, saying that “this class really helped build your confidence in a constructive way, instead of just throwing a bunch of stuff at your face and hoping that you caught it.”

Men also discussed how the instructors’ pedagogical styles influenced their capability. A White man explained how Roger’s presentation of the content made him feel capable of accomplishing the work,

> It's all about presentation. Most classes that we take as engineers will kind of carry that same degree of difficulty. But this class has demonstrated that there is a way to manage that degree of difficulty. There is a way to manage that into bite size pieces and show you that you are capable of doing the hard work.

Regarding Amar’s class, a Black woman described how his approach to problem-solving increased her sense of capability that she could succeed in the chemical engineering major.

> I think it made me more capable of succeeding in chemical engineering just because it really pushed my problem-solving skills. It was very different than other classes such that there was... Like I said in the beginning, there was this learning curve we had to get over in order to succeed. And that was in terms of the problem-solving method that we were using. And just the approach of understanding what I know and what I don't know and being able to apply that to different scenarios, and just the knowledge that I obtained in this class is significantly different than all my other classes that I've had before.

Reflecting further, she added: “And I know it's different than what I'm going to be learning in the future. So I think it definitely made me more successful in terms of chemical engineering.”

I observed a contrast between how women and men talked about influences on their sense of confidence. White men in Amar’s course described how the curriculum helped them increase their confidence because they believed what they were learning was important to being engineers. For example, a White man explained that the curriculum “tied” concepts together which made him feel more capable in chemical engineering,

> I do feel more capable. I also really enjoyed this class. I think it helped make a lot of ... Our last few classes we've taken are very theory-heavy, apart from our labs and design classes, so it helps tie a lot of industrial things together, it's a lot easier to think about. So, I do feel more capable.

Other White men voiced similar assessments. One agreed that the course helped him connect certain concepts together which increased his confidence,

> I think this course has helped to tie together a lot of different parts of chemical engineering and has helped tie a few knots around some of the gray areas of industry. And so, I think the course has increased my confidence a little bit.

Another White man described how he felt more capable because he felt “you can never learn too much” and felt that the content in Amar’s class was helpful to his future as an engineer.

An Asian man in Amar’s course directly attributed his increased confidence in his Chemical engineering coursework to Amar’s teaching,

> I think there have been ChemE classes that we've taken that are more challenging than this one, and maybe even more poorly taught, so I think, if anything, this class was not just a confidence-booster, but it was challenging, but in a good way that made me feel like I've gotten through a lot of the stuff in the past and I've gotten through this class, so definitely there's more confidence that comes with that. So, overall, I would say that it was positive in terms of building confidence in chemical engineering.

Grading and Feedback

Roger’s method of grading, in which he awarded points and gave immediate feedback to students through quizzes that could be attempted multiple times, contributed to both women and men participants’ increased confidence and feelings of capability in the course. Roger set up his course so there were opportunities for students to improve their grade throughout the term. Several White women discussed how this assessment approach increased their confidence. One described how her confidence grew throughout the course making her feel positive about her future capability in engineering:

> I think I felt more capable, just because it's also the idea of getting the quizzes right and then getting that good grade I think has given me a lot of hope in myself and being able

> to figure out those problems, even if I don't get them right the first time, being able to backtrack and kind of figure out where I'm going wrong, that troubleshooting. So, I think I've gained some confidence in myself in doing those problems and just for what I can do in the future.

A second White woman explained how Roger's approach to grading contributed to her performance and her sense that she was learning which gave her confidence to feel that she could be an engineer,

> Having the multiple tries on the questions makes me feel like I'm really learning it and seeing my grade be not as low as some of my other courses definitely boost my confidence and makes me feel like I'm actually finally understanding how to be an engineer. And I'm starting to actually see some success in my career path.

Two Asian women compared Roger's course to other courses they had taken where grades were curved. One observed,

> Yeah, I like how this course is formatted, with the quizzes, so when you get it right, you're like, "Yeah, I get this concept," because I feel like for a lot of other engineering classes I've taken, if you get a 50%, you're above the curve, and when you get a 50% on a test, it's pretty disheartening. So, I'd say that being able to do these quizzes and actually get the correct answer, it makes me feel more confident that I'll be able to do it in the future.

The other agreed that grading curves were discouraging in other engineering courses and felt that grading in Roger's course made her feel more capable in engineering, I did take [ChE] classes, and, after those, I felt pretty disheartened because the curve was so low, and, honestly, the grading scale was not that great, especially I took ChE 301[4]. So, after this class, I definitely feel more capable as an engineer overall."

Most women and some men in Roger's course appreciated getting immediate feedback because they were able to see what questions they missed in the quiz format and were able to re-take the quiz to improve their grade. Students felt that it helped build their confidence so that they could successfully complete the material. A White woman shared how getting immediate feedback contributed to her positive feelings about the course,

> The immediate feedback and getting to figure things out definitely helps me feel more like I know what I'm doing, and when going into lecture or something and someone asks a question, and then hearing the explanation and answer, it makes you feel like, "Oh, yeah, that makes sense," and you start to form those... yeah, it definitely makes me feel like I might be okay. I might not fail every course in chemical engineering.

Immediate feedback on the quizzes also increased another woman's confidence,

> I think the way that the class is set up, where we're able to have more success, in the things that are homework that we have routinely, and especially with the immediate feedback, it's easy to see that you're doing something right. And so it builds your confidence and then it's just, it's a positive cycle in a good way.

A third White woman appreciated the immediate feedback that the quizzes provided because she knew she was performing well in the course which made her feel more capable of doing well overall in the course,

[4] Pseudonym used to mask course name

> I think the immediate feedback on the quizzes has made me feel a little bit more capable, because I mean, I know I'm doing well in the course. I know I'm not going to fail this course and that's not necessarily something I've struggled with, but there is a confidence boost that comes with that.

Another referenced the confidence she gained as a result of receiving regular feedback in Roger’s course,

> I feel pretty capable, I would say. In the scope of this course, the format makes it really easy for me to feel confident when I get things right. And I think also because like it's immediate feedback, I guess, I am very good at I guess just remembering where everything in the courses is. So I can go back and find formulas if I need them.

Men in both courses also described how grading and feedback increased their sense that they were both confident and capable of succeeding in Chemical Engineering. A White man in Roger’s course commented on Roger’s quiz policy,

> So with this class, the format of having those multiple quizzes and having the initial quizzes being unlimited attempt, that really helps me be, "Okay, I'm really solidifying this material." While for other classes, you're really just learning the material. And then, it all accumulates to these bigger exams. And in those classes, if you do well on them, then that really gives you a feeling of accomplishment and it boosts your confidence a lot.

Several women and men in Roger’s class further described how the immediate feedback Roger provided affected their confidence. A White man explained:

> So I feel like the immediate feedback does kind of help you feel a bit more capable, because it's either you immediately know you don't know it, and then you can go back and correct that. Or you know it and you can go on.

Roger’s course also seemed more “manageable” to another White man, who also felt more capable as a result,

> They've laid this course out so it's like you can see looking what you've done it's like, this is hard stuff to do, but you're also can see where it's like, they're giving you step by step how to get there, how to do it. And it feels completely manageable to do this content, despite the fact that you can still look at it you're like, "Man, that is hard stuff," but you're doing it.

Overall, Roger’s course design and teaching practices provided students with the opportunity to improve their grades by re-taking quizzes and getting feedback on problems they missed. Both men and women in this course attributed an enhanced sense of capability and confidence to do engineering coursework and the chemical engineering major to his instructional approach. Roger’s approach was rooted in ensuring that students were able to grasp the material. Dewsbury (2018) refers to this pedagogical approach as maximizing “deep learning”.

Amar used more traditional forms of student assessment, including two exams and weekly homework problems. He also, however, used group problem-solving during class time, with self-selected groups meeting after the lecture portion of each class. Student groups had to complete problems that were turned in at the end of class. Amar did not discuss the feedback students received on their exams and some students complained that the workload was too high. In response, Amar made changes to this based on feedback he received from the students in his course. He scaled back the problems so they were shorter than before. He also reduced the homework problems. Amar showed “empathy” by listening to the needs of the students and actively changing aspects of the course, which Dewsbury (2020) indicates is an important part of inclusive teaching.

Confidence in Learning in Roger's Course

Students' perceptions of the level of difficulty of Roger's course and how well they believed they were doing in the course affected their sense of capability and confidence. Women felt that their understanding of the material (their learning) gave them the confidence to be successful in future engineering courses. A Black woman felt that the knowledge she was learning made her feel confident that she could apply the skills to an internship. A White woman shared how she felt more capable because she was performing well in the class and understanding the material,

> I actually understood this class, which is one of the few supposedly harder classes that I've felt that way about. So it's not like it's life-changing or anything, but it definitely made me feel a little bit more capable. Not that I'm out here getting 100 on the exams or anything, but just to know that I can get through the homework if I have to on my own with a lot of time put in, it's made me feel like I'm not always below average, I guess you could say, in terms of doing well in the classes.

Another White woman also discussed how her grades in this course and others affected her self-confidence in engineering,

> I'm feeling more capable, because this class gave me confidence. I have an A in the class now, so I'm like, "Yay, maybe I can do this," whereas last semester, I was like, "I don't know if I can do this."

Other women who felt that they were able to understand the course content also reported increased confidence. Another White woman shared how her understanding of the course content affected her belief that she could succeed in later engineering courses,

> I would say I feel like more confident in my ability in future classes because I really understand the basics of this class and it's not going to be the type of thing where I pass a final and I'm like, "Oh, thank God, that's over." I actually learned a lot in this class that I can build on.

Some women of color, including Asian women and a Latina, also described feeling confident not only in their current course but in future engineering courses because they were doing well in Roger's course. An Asian woman discussed how her peers had shared with her that ChE 101 was extremely difficult and her success in the course made her feel more confident that she could be successful in chemical engineering,

> I know people in the past, or Chem Es in the past, have always said [ChE 101] was one of the hardest classes in Chem E to take during your track, so the fact that we have all been doing well and learning the material, it gives me confidence that I can learn the material, moving forward, especially if this was supposed to be a really hard class, I feel better about pursuing the Chem E major.

Another Asian woman in Roger's course further explained how she gained confidence because of Roger's instructional style that made it conducive to her learning, "significantly more confident, just because of the style of learning, and I feel like, in this class, I really had a better understanding with most topics, and that just gave me a lot more confidence." A Latina explained how she understood the content more than other classes she had taken which made her feel more capable in chemical engineering,

> I think it made me feel more capable, honestly. This was a very intimidating semester and I had opposite experiences in other courses that I'm currently enrolled in. And so to be able to be like, "This is a hard subject and I feel like I have a decent grip on

> understanding it." Maybe not like some of the more complex math problems or whatever, but it feels a lot more accessible in terms of just kind of the base information. And so then it feels more easily that I could build on top of that knowledge. So yeah, I think it gave me a little bit more confidence than maybe some other classes made feel.

A Black woman in Roger’s course connected her confidence in her mastering the “core material” to the ability to be successful in pursuing an internship:

> When you go and try and find an internship or whatnot, they're like, "Have you taken [ChE 101]?" And so now, like, "Yeah, I have." So I think that's the main reason why I feel so confident as well, just because knowing that I'm starting to get the core material down.

Group Problem-Solving in Amar’s Course

In Amar’s course a majority of the students enjoyed working with their group and appreciated the support they received from their peers and the ability to ask each other questions, but students had mixed reviews about whether or not the group problem-solving contributed to their learning. Some students did not recognize they were learning in the groups and did not view the support or the ability to ask their peers questions as a learning process. They viewed their learning as connected to the product: getting the answer right or understanding the concept. A White woman shared how she appreciated she could share her confusion about the content with her groupmates but did not feel the group work helped her learning

> sometimes it's good to know that after a hard lecture, you're like, ‘What the hell was that? I don't know what that was.’ To find out that everyone else feels the same makes it feel a little bit better, I guess, boosts morale. But I guess, specifically, as it pertains to learning, no.

Another White woman described how she felt that the in-class problems were useless because she was not able to attain the end product by answering the problem correctly,

> I feel like if they were a little bit easier, I would feel better about it, just because when we don't finish an [in-class problem] or there's a problem we just really don't know how to do on it, it just feels useless. If it was something that was actually attainable, I think it would make me feel a lot better.

Some students believed that the group work was not conducive to their learning because they felt too rushed and did not feel they had adequate time to process the information. A White woman explained how even after Amar scaled back the problems, the in-class problems were still too long,

> Most of the time, the [in-class problems] are too long to be able to explain the things that the people in your group don't understand, so if someone's lost, it's just much more time efficient for the one person who understands it to either send a picture of their work or write that problem up than it is to actually learn together just because based on our timeline, we just don't have time for everyone to understand.

Other students felt that they were able to learn from their peers and that it solidified their understanding of the concepts. In response to my question about whether or not she felt the group work in Amar's course was conducive to her learning, a White woman shared, "It definitely does help in my experience, just like forcing you to use the knowledge right after you learn it instead of just drifting away to Neverland or whatever."

The groups also had different processes of working through the problems, so this potentially contributed to feelings around learning. A Black/Latinx woman explained how her group structured the time to assist everyone's learning,

> We solved the problems individually at first and then confirmed answers and problem-solving techniques towards the end, just so that way, we knew that we were learning and understanding the material ourselves and how to solve problems, but then also verifying that we actually had the correct solution at the end.

Yet, unlike the students in Roger's course, students did not connect their learning to this instructional practice (working in groups) or how their learning contributed to confidence in the chemical engineering major or a future career in chemical engineering.

Summary

Both Roger and Amar incorporated aspects of equitable teaching practices in their courses, which facilitated a connection between them and their students by explicitly welcoming students into the class discussions (Tanner, 2013). This was evident in the way that both Roger and Amar were honest about their own struggles with some of the course content. Roger and Amar also focused on presenting the material clearly and by demonstrating the applicability of the concepts to ensure students had strong conceptual understandings of the material. This engagement in "deep" learning contributed to students gaining confidence and feeling more capable in the courses as Dewsbury (2020) suggests.

Roger chose his grading methods, specifically the use of quizzes, instead of exams, and the practice of giving students multiple attempts to complete each quiz, both to help students learn but to also decrease stress. Students in Roger's course particularly discussed how they felt they were learning in the course which made them feel more capable and confident. As Dewsbury (2020) discusses, instructional strategies focused on the notion of "deep" learning that respond to students' needs (for example, feedback on their learning) contribute to an inclusive classroom climate.

Limits of Inclusive Teaching

A subgroup of four students (two White women and two men of color) in Amar's course were ambivalent about the course because it was difficult -- just like other engineering courses they had taken in the past. Although they appreciated Amar's teaching style, they did not indicate that it helped them feel more capable or confident in the course because they described themselves as struggling consistently in the course. Another subset explained that although they appreciated the instruction they received, they already felt highly capable and confident and their experiences in these courses thus did not increase their feelings of capability or confidence in engineering. In this section I describe how students based their sense of capability and confidence on their experiences in other courses and in the major as a whole to contextualize their feelings of confidence.

Ambivalence in Amar's course

Two women in Amar's course, which is a course that is taken toward the end of the major, shared that they did not feel more capable or less capable after taking the course especially because they felt they were encountering challenges in the course. One White woman connected her feelings to the nature of the online course format rather than to instruction. She felt it was difficult to be successful in the course without the immediate support and help from her peers that she would be able to get if the course was in-person which led her to feel ambivalent about her preparedness in engineering,

> I feel pretty neutral. I think not being in person, having people to just immediately talk to in class, that's definitely been a hit for me, it made it more difficult for me. I always feel bad reaching out to people and asking questions on things, so that definitely puts me

> behind. I should ask more questions to friends and peers. Yeah, I don't really think I feel more prepared, but I also don't really feel less prepared.

A second White woman in Amar's course compared the course to other engineering courses and attributed her feelings of ambivalence to her challenges with understanding the material,

> Compared to, say, the two ChemE courses we took last semester, where ChE 301[5] was very easy for my mind to understand and then ChE 302[6] made zero sense, this is right in the middle of those two, where I get most of it but not all of it. Yeah. I mean, the professor does a really good job, obviously, with trying to explain all the material that I don't quite understand. But some of it will just always be over my head a little bit.

Ambivalence may also have been a result of students nearing graduation as one White woman commented on the culmination of difficult classes in the major,

> Personally, I feel pretty much the same because I feel like we're in the home stretch here, one year left. I think, personally, that most of the classes, the harder ones have been done with, and this one's just kind of the end of it.

Men of color also felt that because they were so close to graduation, they had no choice but to keep going. A discussion between a Black and Latino man about Amar's course, as they reflected on their majors, prompted the Black man to conclude that "it was too late to turn back now". The Latino man felt that he had a "love/hate" relationship with Chemical Engineering classes. He explained how the course had not changed his conflicted feelings about the major, "For me at least, this class in particular, if you're talking about just this class, it really hasn't changed anything. I know what to expect from chemical engineering."

[5] Pseudonym used to mask course name
[6] Pseudonym used to mask course name

No Change in Confidence or Capability

The subgroup of four students who described already feeling highly capable, explained that while they appreciated the instructors' pedagogical choices and in Roger's course, the grading and feedback, they did not view the instruction as contributing to any increase in their capability or confidence. These students already felt quite confident and capable in their engineering courses. One White woman elaborated on how she felt "probably equally capable" to other engineering courses but explained that she appreciated Amar's teaching style compared to other professors she had taken courses with,

> It's nice to have a professor that does a good job explaining things because I think in the past that can be frustrating. When someone who you know has so much more experience than you gives you an explanation that you still can't understand can be disheartening. But I don't think Professor [Amar] has ever done that, which helps my ego, at least.

Three students in Roger's course expressed similar sentiments. A Black/Latinx woman described how she was equally confident with other courses she had taken in engineering although she also felt that the structure of the course had helped her learning:

> I definitely don't think it had a negative impact, but yeah. I feel like it's more so neutral. I've always been very confident in myself and my abilities. And I mean, the format of the class has been very helpful to my learning. I really appreciate that and I think it's helped me grasp [name omitted] a little bit better. But I mean, as far as me thinking I can be more successful as a chemical engineer after taking this class, I think it's about the same.

Two White men also described how they felt equally capable and confident compared to other engineering courses. A White man in Roger's course elaborated on what another student in his group interview said, "I don't think it's different. As [name omitted] was saying, just establish that I can continue on this path and I am able remain successful as the classes get harder." Another White man, also in Roger's course, offered, "I think it's the same, in the fact that I haven't really had an engineering class that has made me think that I can't succeed." He went on to explain how his confidence was high in Roger's course because the quizzes helped solidify his understanding, but in other courses, he felt a greater sense of accomplishment for being able to complete "big" exams,

> ` So with this class, the format of having those multiple quizzes and having the initial quizzes being unlimited attempt, that really helps me be, "Okay, I'm really solidifying this material." While for other classes, you're really just learning the material. And then, it all accumulates to these bigger exams. And in those classes, if you do well on them, then that really gives you a feeling of accomplishment and it boosts your confidence a lot.

Lack of Capability and Confidence in Amar's course

Three students, who were near graduation in Amar's course, connected their negative experiences in the course to the content rather than instruction. They felt that the content was hard, had lost confidence, and therefore were not sure if they could pursue chemical engineering in the future. For one individual, the online format of the course was also a concern. These students expressed lower feelings of capability as a result of taking the course and a lower desire to pursue chemical engineering. A White woman described how her poor performance in the class made her feel that something was "wrong" with her and she felt less prepared to enter the field of chemical engineering. She explained that she felt less capable than in other courses,

> Most of my class, obviously, took this class last year, and from my friends and my group, everyone was like, oh, [ChE 201] isn't that bad. Compared to the other ChemE classes, it's a lot easier. I feel like I have not done as well on this class as I have in all the other

> classes. I'm just like, is something wrong with me or is this class harder than it was last year. Mostly just because of my situation, I feel less prepared.

An Asian woman also felt the difficulty of the course and her performance, along with her indecision about which engineering subfield to pursue, all contributed to her lack of certainty and confidence regarding her future in chemical engineering,

> It's definitely harder conceptually to grasp a lot of the things in this course and I'm like, "Oh God, I really don't want it to have to do stuff with [name omitted] in my career because I really don't know what's going on." And so that is a little bit... I feel like it has made me a little bit less confident in what I want to do or something like that. But again, I'm not really a hundred percent sure about exactly which field I'm going to go into, so it's not like, "Oh my God, I really can never like do this or whatever." It hasn't made a huge impact, but a little bit.

She further explained that the time and energy she put into the course was frustrating because she was not performing as well as she expected which contributed to her low confidence,

> I think that my experience in this class has been, I work, I spend a lot of time on it and I don't get the results that I want to and that's been frustrating compared to our other chem E classes where I understood for some of them, "Oh, I didn't put that much effort into that class or I didn't really care that much about that class." So like, "Okay, it makes sense." But for this one, I spent so much time on it and I do okay.

A man who chose not to disclose his race explained that the online nature of the course coupled with his challenges with understanding the material contributed to his lack of confidence in his preparedness to pursue a career in Chemical engineering,

> I'm nervous because I think this course is supposed to make me a very good chemical engineer. I'm nervous that I will not be a very good chemical engineer out of this course because it's online and because I'm not doing as well as I would like. And it's not even as well as I would like, it is, I didn't do all of the homeworks because I did not know how to start the first problem and I just couldn't get around that.

He added,

> So, being online for the fundamentals of what we're going to be doing in our careers, is worrying. Something that I really need to figure out on my own like, "Am I really screwed? Or am I going to be okay?" Because it doesn't feel like I'm going to be okay.

The student went on to explain that he had a 68 average in the course and despite knowing that the class was "curved", he did not feel the confidence to go and be a chemical engineer in industry.

Summary

Although Amar's class integrated some aspects of inclusive teaching, it was traditional in its use of exams and homework problems. Although Amar "listened" to his students and was empathetic when they indicated that the workload was too high, his methods of grading and feedback were consistent with those of other engineering instructors; students did not report that these practices contributed to their feeling capable or confident in the course. It appears that only including some aspects of inclusive teaching may not be enough to support all students in the classroom, particularly if traditional aspects of engineering culture remain, such as grading on a curve and designing exams that include questions about concepts that differ from those shared in class lectures, discussions, or problem-solving activities.

Desire to Remain in Chemical Engineering

Women discussed the content of the courses, Roger's connection of concepts to the real world, and feeling that they were learning as contributing to their desire to remain in chemical engineering. They also felt the courses prepared them for careers in chemical engineering and affected their sense of excitement and readiness to pursue a career in Chemical Engineering. On the other hand, a group of three students in Amar's course felt that the content had only further solidified their desire to not continue in chemical engineering.

Effects of Content, Instruction, and Learning on Women's Desire to Remain in the Field

For a White woman in Amar's course, she explained how she was able to connect the content to what she may do in industry which made her feel prepared to enter the Chemical Engineering industry,

> We did a lot more coding this semester, which I know is important in real life. So that made me feel a lot more capable for the future. And I guess like, as we come to completion, this is kind of the first time I felt like an actual connection to chemistry. So I feel like we're wrapping up and putting a lot of the central ideas together. And so that makes me really excited, because it basically is one of the last core classes that we have until graduation. So it made me feel ready basically. Like I know a lot of companies, like [ChE 201] is the big class they want you to have taken before having a big internship, because this is like the class where you really learn a lot of the core principles that you use later on. So I think it definitely helps me personally.

Roger's incorporation of DE&I and examples applicable to real world situations increased another White woman's desire to continue in chemical engineering,

> I do also love how in this class we talked about different DEI topics as well, and the applications, what we're learning, statics and fluid flow, to like dance and stuff like that. I just feel like overall, it kind of increases my motivation to learn what I'm learning, increases my interest in that part of the field overall. And yeah, I just think it's made a definite positive impact on my thoughts on ChemE this year.

The applicability of the course content to work in engineering resulted in a greater sense of comfort and preparation for two Asian women in Roger’s course. One of these women elaborated,

> Personally, for me, for this semester and last semester, I feel like these classes are getting to more of what we would apply as chemical engineers if we choose to go into industry, so I do feel more comfortable, and I feel like I could possibly work as a chemical engineer and now have that knowledge.

The second Asian woman described how some courses left her and her peers feeling as though they hadn’t learned much or that their learning was a struggle. In contrast to the negative experiences she described in other courses, she felt she was not only learning but learning what she would need to know on the job. This contributed to her sense that she was prepared to pursue a job in chemical engineering,

> I think for me, I feel more capable in succeeding in chemical engineering, but that's also because, from talking to upperclassmen and their experiences in this course with another professor, all of them said, “oh, I didn't really learn anything in the class.” Or like, “it was a lot, it was really difficult.” And it was just generally a negative experience for all of them. So I think based on that and knowing how important [name omitted] is in chemical engineering in general, because it's something that you carry through in a lot of jobs or

> experiences you'll have in the future. I feel like I'm a lot more prepared for any future experiences from this class.

A Latina nearing graduation in Amar's class similarly contrasted her experiences in his course with others,

> I feel like this is probably my best class so far. This is my most enjoyable class too and maybe because the content is a little bit easier than in the past, but it just feels like I'm more capable of succeeding going on forward.

Clarity on the Desire to Remain in the Field in Amar's Course

In Amar's course, three students, a Black woman and two Asian men, felt that the course content had clarified for them that they did not want to pursue chemical engineering even though they felt they had the ability to do the work. One Asian man felt that the course applied concepts in a way that helped him understand the content but still did not pique his interest in pursuing chemical engineering as a career. Although these students felt highly capable and had high confidence in their abilities, the course helped them realize they were no longer interested in the field. For example, a Black woman explained her feelings about continuing a career in chemical engineering, "I feel more capable, less interested." She explained further, saying "I feel like every semester gets a little more invalidating. Every time you pass, it's just, for me, personally, every semester it's also like I don't know if this is what I want to do with my life."

An Asian man also shared similar feelings,

> Yeah, I would say it's, at least for me, similar, positive in that I don't doubt my ability to do it because we are getting through a tough course and all of that. I guess the flip side of that, it maybe doubts if I'm as interested in pure chemical engineering, but that might be off the topic because this doesn't seem like something I would want to do in the future, so

> maybe the content of the class made me less positive about ChemE, but not in a ability-wise way.

Another Asian man also agreed that he felt more capable but did not feel that it made him more interested in chemical engineering as a career,

> I don't know if it was any more helpful in making me more enthusiastic about doing the topic. But it was a good, more practical kind of course that applied all the concepts in ways that made a lot more sense in theoretical things, so, that part, I enjoyed.

Conclusion

In this chapter, I explored students' descriptions of how their personal sense of capability and confidence were affected by their perceptions of the learning environment. Overall, instruction, grading, and feedback seemed to contribute to students' sense of confidence and capability for both men and women. Students developed confidence in their learning which also contributed to them feeling more capable in the courses. Although there was a subgroup of students that did not gain confidence, they reported that they appreciated the methods of instruction used in the two courses. Students who felt lower levels of confidence and capability attributed it more to content rather than instruction.

Although I did not find a connection with sense of belonging and women's desire to remain in the field of chemical engineering, I did find a connection with women's capability and confidence in the course. Women's desire to remain in the field was influenced by the content of the course, instruction, and their confidence in their ability to learn. Their reflections suggest a relationship between more inclusive pedagogy and grading practices that provided immediate feedback which led to increased feelings of capability and confidence. Both Roger and Amar welcomed students into class discussions (Tanner, 2013) by being honest about their own struggles with the material. Students felt that they presented the material clearly and also demonstrated the applicability of the concepts which are aspects of “deep learning” (Dewsbury, 2020). Particularly in Roger’s course, the use of quizzes with unlimited attempts allowed students to improve their grade throughout the semester, which also contributed to their “deep learning”. Students’ performance in the course contributed to their confidence that they were or could be successful in a chemical engineering major or job. This aligns with results from the survey data. While the overall analysis that combined students’ responses for both courses showed that women’s engineering self-efficacy improved over the period of the course, the change was not significant. An examination of the descriptive statistics, however, shows that the means from the pre- and post- engineering self-efficacy measure in Roger’s class improved; in Amar’s course, they did not. The difference could be attributed to the different instructional style and/or grading structure that Roger integrated into his course.

Amar’s course was also structured differently than Roger’s course. It included a lecture component that preceded group work. Students had mixed feelings about the groups. Although they liked being able to connect with peers that they knew, some students felt that the problems were too difficult to do in the amount of time allotted, which made their learning feel rushed. Still, a small number of students felt that this group problem-solving promoted their learning because they were able to discuss the problems with their peers. These mixed responses to the problem-solving groups, with problem difficulty and time as complicating factors, may have contributed to why the survey results indicate that students in Amar’s course had lower self-efficacy at the end of the course.

It is worth noting too, that students’ assessments of self-efficacy may be affected by more than the teaching practices they encounter in a particular course. Four students in Amar’s course described his instruction as beneficial but had feelings of ambivalence regarding the course due to their overall experiences with engineering in which they felt that they were consistently struggling. Another subgroup of four students in Roger and Amar's courses indicated that they already had high levels of capability and confidence and felt the same as in other engineering courses. Although they appreciated the instructors' teaching styles, they did not feel it changed their confidence or feelings of capability.

A subgroup of three students in Amar's course indicated that their struggles with the content in the course, and for one student the online nature of the course, made them doubt themselves and their abilities. As they were nearing graduation, they were worried that their performance in the course would affect their success in the field of chemical engineering.

The results in Amar's course demonstrate that there are limits to inclusive teaching. Although Amar showed empathy to his students by scaling back the work when he realized that students were struggling and giving him feedback, the way he graded and gave summative feedback was similar to other engineering instructors. By only including certain aspects of inclusive teaching in your pedagogy and showing empathy, it may not be enough to support a wide range of needs in a classroom. Therefore, it may be of importance to consider equitable teaching practices combined with inclusive teaching.

Women in both courses shared how the course content, instruction, and their learning contributed to their belief that they could be successful in the field of chemical engineering, and some indicated that these experiences cemented their desire to remain in chemical engineering. Yet three students -- a Black woman and two Asian men -- who reported high levels of confidence in their abilities to do engineering work, also reported that they no longer had a desire to remain in the field. These students in Amar's course said their desire to pursue chemical engineering after graduation had decreased even though they felt very confident of their abilities in the field because the course clarified for them that they no longer wanted to pursue chemical engineering. This finding reveals a nuanced connection between confidence, capability, and desire to remain in the field. Although students may have high levels of confidence and capability, other factors, such as interest, may contribute to their desire to remain in the field.

Chapter 8 Study Contributions and Implications

This mixed-method study used a feminist lens to guide the research on women's experiences in engineering classrooms with instruction. The study included observations of 63 class sessions of two courses, 68 group interview participants, two instructors, and 170 survey respondents in two online, undergraduate chemical engineering courses. The focus on online courses was a necessity driven by the COVID-19 pandemic which resulted in many U.S. colleges and universities shifting to remote instruction in the 2020-2021 academic year. Yet, studying engineering courses was, in contrast, intentional.

This research contributes to two main gaps that persist in the literature: 1) the effects of engineering instruction on the socioemotional outcomes of marginalized students and 2) students' socioemotional experiences with online instruction. My mixed-method study provides a comprehensive analysis of instruction, particularly online instruction, and its effects on women. The main contribution of my study is an in-depth understanding of how undergraduate women experience engineering courses and how these experiences affect their sense of belonging and desire to remain in the field, and their engineering self-efficacy.

Currently there is no framework to understand the effects of instruction on socioemotional outcomes such as self-efficacy and sense of belonging, or how these may vary by gender. Current literature is limited in that it focuses on academic self-efficacy in STEM majors rather than classrooms (see Clark et al., 2021; Hackett et al., 1992; Jones et al., 2010; Marra et al., 2009; Verdín, 2021; Williams & George-Jackson, 2014). Although there are some studies in STEM that focus on instructor/student interactions and self-efficacy (see Riegle-Crumb et al., 2020) and belonging (see Harben & Bix, 2020; Lester et al., 2016; Rainey et al., 2018; Sax et al., 2018; Verdín, 2021) these studies do not specifically focus on the effects of instruction. In addition to the findings from a mixed method approach, the contributions of this study include a new conceptual framework to guide future studies of instruction on women's experiences in engineering courses and their socioemotional outcomes in those courses. The framework is specific to chemical engineering but can potentially guide studies in other engineering and STEM disciplines.

In addition to these scholarly contributions, this study contributes to finding ways to further support women who enroll in an engineering major and seek to pursue engineering as a career. The field recognizes that identifying solutions to complex problems requires diverse perspectives and backgrounds (American Society for Engineering Education [ASEE], 2022), but has struggled to retain women in undergraduate majors. As this research shows, instructors and their teaching practices influence how women view themselves and their abilities and can affect their interest in engineering careers. Improving engineering instruction appears to enhance the experiences of women students and may positively affect their career trajectories in engineering.

Overview of the Study

The main research question that guided this study was the following: *How does instruction and interactions in an online engineering course affect women's engineering self-efficacy, classroom sense of belonging, and desire to remain in the field?* The following sub questions are considered to answer the broader question:

1. What is the nature of the learning environment the instructor plans to establish and enacts during the course?
2. How do students perceive the instruction provided?
3. a. How do students perceive the learning environment?

   b. How do perceptions of instruction influence their perceptions of the learning environment?

4. How do students' perceptions of the learning environment relate to students' engineering self-efficacy and course sense of belonging?
5. a. How does engineering self-efficacy and course sense of belonging relate to desire to remain in the field?

   b. Do perceptions of the learning environment, engineering self-efficacy, course sense of belonging, and desire to remain in the field vary by gender?

   c. Do these vary for women based on race/ethnicity?

Using a social constructivist epistemology, I sought to 1) understand how instructors engaged in their pedagogy and decision-making in their engineering courses, 2) capture teaching practices that made women feel included, and 3) understand how the nuances of sexism and racism impacted women's experiences in engineering classrooms. I was able to explore these goals in my research through group interviews based on gender/race categories, a pre- and post-survey, pre- and post-instructor interviews, and online class observations. Data was collected over a semester in which both courses were taught.

Using feminist theories as a framework for my study allowed me to explore how aspects of a toxic engineering culture are rooted in power and seep into classroom contexts, and how instruction might also shape the interactions between instructors and students. Through my analysis, I uncovered how the teaching practices of two chemical engineering instructors contributed to women's perceptions of the classroom climate, as well as their capability and confidence in themselves and their abilities. I also found that interactions with instructors, and especially men peers, shapes how women in engineering perceive their engineering skills and abilities which, in turn, affects their experience in the engineering classroom. I began my study with the assumption that I would be gathering evidence of exclusionary teaching and negative peer interactions because of the influence of a toxic engineering culture. Yet, both instructors engaged in aspects of inclusive teaching. The instructors' inclusive teaching efforts had an impact on many women participants' experiences and socioemotional outcomes. Women, and some men participants, contrasted their experiences in these courses with their experiences with instructors and peers in other engineering courses, and expressed appreciation for the kinds of teaching practices both instructors engaged in.

Quantitative data indicated that reports of inclusive classroom experiences appear to contribute to increases in women's engineering self-efficacy over the course of the semester, and analysis of the survey data demonstrated a significant positive relationship between classroom sense of belonging and engineering self-efficacy. I was not, however, able to statistically assess how engineering self-efficacy and classroom sense of belonging related to desire to remain in the field because of a lack of absence of variation in the dependent variable. Additionally, although I was able to study how classroom sense of belonging and engineering self-efficacy differed by gender, sample size limitations for women of color precluded statistical intersectional analyses of variations by race/ethnicity. I discuss my findings in greater detail in the section of this chapter that presents a new conceptual framework for studying women's experiences of inclusive instruction and my propositions for future research in the next sections. I conclude with a discussion of recommendations for future research and my study's implications for practice.

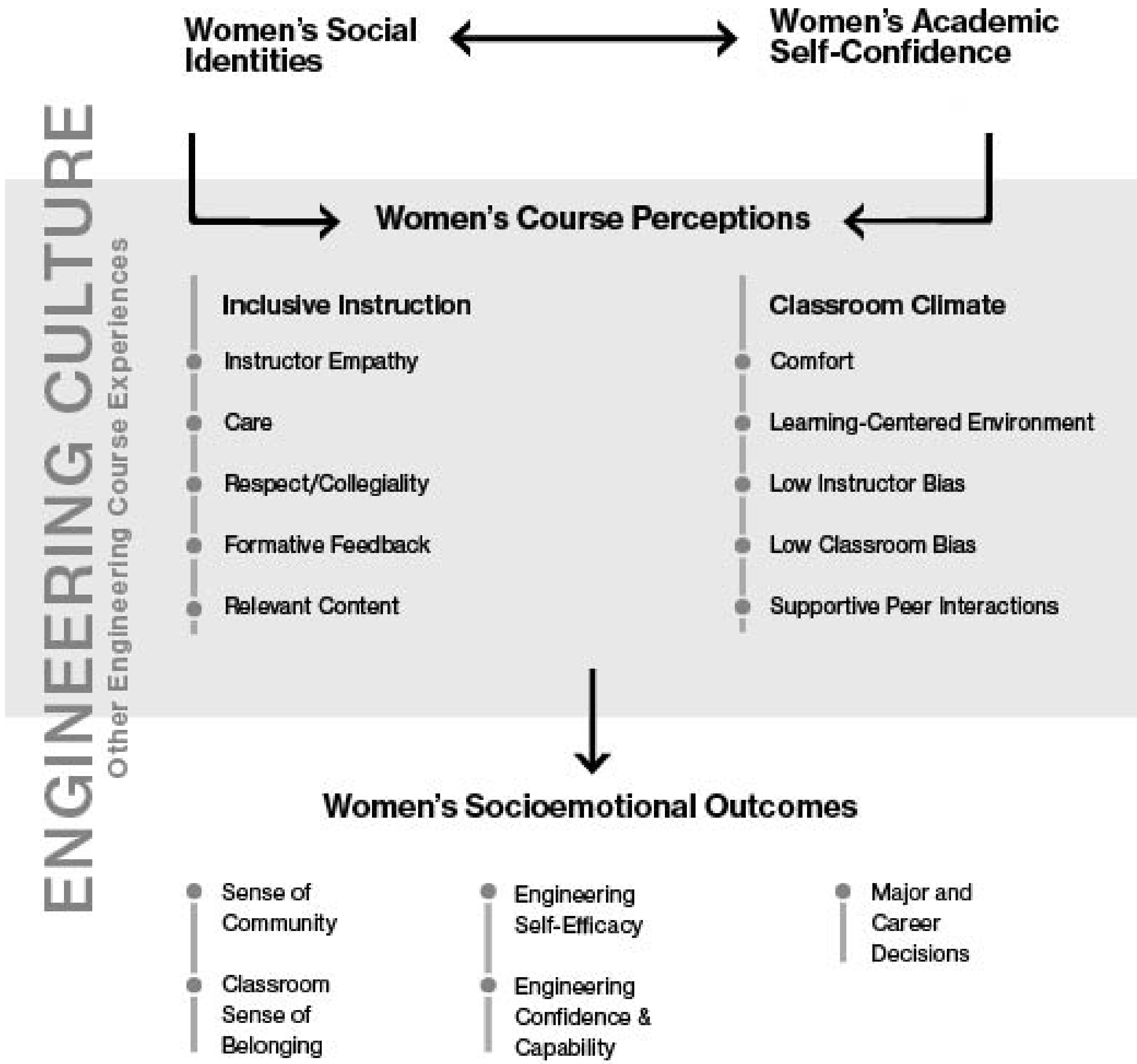
A New Conceptual Model: The Effects of Inclusive Instruction on Women in the Engineering Classroom

My analysis led me to greater understanding of the effects of instruction on women and how men peers also contributed to the experiences of women in the engineering classroom. The framework I developed to explain these concepts and their relationships are depicted in Figure

8.1, “The Effects of Inclusive Instruction on Women in the Engineering Classroom.” To date, a framework that specifically examines instruction in engineering classrooms does not exist. Consequently, this framework has the potential to fill a gap when conducting research on marginalized populations in engineering classrooms. The framework merges findings from the qualitative and quantitative study components while also utilizing feminist theory to inform my understanding of the processes that occurred. This also led to a set of propositions based on the framework that can guide further research. Each component of the framework is described in the next paragraphs and a discussion of the propositions follow.

Figure 8.1

The Effects of Inclusive Instruction on Women in the Engineering Classroom



Engineering Culture and Other Engineering Course Experiences

My conceptual framework assumes that engineering culture operates in engineering courses as depicted in Figure 8.1. The dimensions of engineering culture that I observed and were prevalent in this study included values of meritocracy, objectivity, neutrality, and superiority, as well as the influence of patriarchy. Although these were my observations, I acknowledge that students may not interpret engineering culture in this way and that students experience it differently. But for the purpose of this framework, the assumption is that engineering culture can be toxic and, in this study, students described engineering culture in negative ways. The influence of engineering culture on students in classrooms was especially apparent with their discussions of other engineering courses that shaped their perceptions of their experiences in the two courses in this study, typically in terms of the contrast in instructors' attitudes and behaviors. Other course experiences with instructors and men peers, who adopted characteristics of a toxic engineering culture, influenced how women felt about their abilities when they initially entered the classroom environment.

Women and a subgroup of men discussed their experiences with other engineering professors who engaged in meritocratic values by grading on a curve and treating courses as ways to "weed" out students. Women also discussed how instructors in other engineering courses behaved in egotistical and superior ways using authoritative tones and talking to them in a condescending manner. Other engineering instructors also appeared to maintain objectivity and neutrality in their classrooms neglecting to incorporate content on matters of diversity, equity, and inclusion.

Both Roger and Amar resisted engineering cultural values through their pedagogy and interactions with students, which was shaped by their own experiences as students. They resisted superiority by discouraging power dynamics and treating the students as equals. Roger went against meritocracy by not grading on a curve but rather giving quizzes that students could take multiple times to improve their learning and their grades. Roger also incorporated DE&I into his classroom, which was a challenge to objectivity and neutrality, which was unlike other engineering courses that the students had taken. Both instructors recognized the patriarchal culture of engineering, with Roger leading a discussion in his class on implicit bias and Amar making sure to include a diverse group of scientists in one of his lectures that included women and people of color.

As engineering culture seeped into the engineering classroom, men's interactions with women peers cast a shadow of patriarchy and white supremacy as men engaged in both gender and racial microaggressions toward women. Women reflected on these gendered microaggressions citing being ignored while also having ideas taken and experiencing "mansplaining" and patronizing attitudes toward them. Black women reflected on how their experiences were not only gendered but racialized and recounted how they were often ignored and treated negatively by both White men and White women. Black women in the study discussed how they sought spaces with other women of color to feel "safe" from these gendered and racialized microaggressions.

Women's Social Identities and Academic Self-Confidence

This new conceptual framework posits that toxic engineering culture, women's negative interactions with instructors and peers in other engineering courses which also adopt aspects of engineering culture, and women's social identities intersect in engineering courses. Specifically, the framework posits that women's social identities, which in this study included race, not only shape their expectations of their courses, instructors, and peers, but of themselves as engineering students. Other engineering course experiences appeared to also shape social identities that students entered the classroom with. In this study, consistent experiences of biased interactions in courses contributed to women's negative self-appraisals and low academic self-confidence in engineering knowledge and skills. My findings revealed that women's negative self-appraisals and low self-confidence were influenced by negative messaging from instructors and men peers particularly in other engineering courses. Many women in the study described feeling intimidated in engineering courses, which caused them to shut down and refrain from asking or answering questions out of fear of being judged by classmates as unintelligent or incompetent and not wanting to interrupt the instructor. These insecurities seemed to lead to an imposter phenomenon in which they felt they did not belong in engineering because they did not have the skillset and abilities (Collins et al, 2020).

The teaching practices and pedagogical choices that Amar and Roger made in their courses positively influenced how women felt about their abilities in the course and influenced their perceptions of the course. For this reason, I include women's social identities, which may include identities I did not specifically study as a component in my model. In this study, gender and race shaped women's experiences in engineering programs due to the cultural values and behavioral norms that characterize the field.

Women's Perceptions of Inclusive Instruction and Inclusive Classroom Climate

The next part of the conceptual framework includes women's perceptions of inclusive instruction and inclusive classroom climate. I use the term "classroom climate" in the framework and in my discussion recognizing that although my research was conducted in online courses rather than in a physical classroom space, I believe the framework could guide studies on both online and face-to-face courses. Prior research supports the assumption that inclusive instruction in these different modalities is similar (Amro et al., 2015; McCarty et al., 2013; Nennig, 2020; Yang et al., 2015).

My qualitative analysis revealed how teaching practices that were perceived to be inclusive contributed to women's sense of capability and confidence. Women in the study assessed their abilities more negatively than men, but also shared that after taking the courses, they felt more capable and confident in their abilities. They attributed their increased feelings of capability and confidence to Roger and Amar's pedagogy and Roger's grading practices and immediate feedback in Roger's course.

Inclusive Instruction.

In my model I identify inclusive instruction as including student-centered teaching, which was measured quantitatively, and the teaching practices that the two instructors employed. In my model I have identified important concepts that emerged from inclusive instruction. The first part is instructor empathy, which reflects how instructors in this study actively tried to resist some engineering cultural values by showing empathy through their teaching. Thus, in this framework, empathy encompasses behaviors such as listening to student feedback on course assignments and the timing of exams, accommodating the needs of students, and recognizing student stress and desiring to alleviate that stress rather than contribute to it.

The instructors also expressed care, the second part of inclusive instruction, for student learning and for the students' well-being. Students reported feeling that they were cared for when their instructors showed care for students' understanding of course content. Students also perceived care in their interactions with instructors in office hours when they showed a vested interest in their personal lives in addition to discussing course content. Instructor care therefore includes behaviors such as showing interest in student learning and well-being. In the third area of inclusive instruction, respect and collegiality, students appreciated how the instructors showed them respect and treated them in a collegial manner. The students felt that the instructors talked to them on their "same level" and were encouraging rather than condescending. They also felt that when the instructors listened to their feedback, they were showing respect for their opinions as students which was not something they experienced in other engineering courses.

Formative feedback, specifically in Roger's course, is the fourth area that contributed to inclusive instruction. Roger did not grade on a curve but rather gave quizzes that students could take multiple times in order to reinforce their learning. Students appreciated that they were always aware of how they were doing in the course and were able to figure out what concepts they needed to focus on. This contributed to students feeling less stressed about their course and appreciating the learning process.

Students' perceptions of inclusive instruction were also influenced by incorporation of relevant content, the final part of inclusive instruction. In this study, this included content related to diversity, equity, and inclusion, and explanations of the applicability of concepts to engineering careers or the world outside the classroom. Students felt that the DE&I discussion and homework problems in Roger's course made them more excited about the engineering content they were learning. Students in both Roger and Amar's course appreciated how applicable the concepts were to their everyday life which made them feel more confident and capable of pursuing a degree in engineering.

Inclusive Classroom Climate.

Comfort, learning-centered environment, low instructor bias, low classroom bias, and supportive peer interactions appear to lead to perceptions of an inclusive classroom climate.
In both courses, women discussed how they felt comfortable in the classroom. Women cited behaviors such as positive reinforcement when they asked and answered questions, validation through the way the instructor welcomed questions, and Roger's use of humor as aspects of teaching that contributed to an inclusive classroom climate.

The other constructs within inclusive classroom climate which included learning-centered environment, low instructor bias, and low classroom bias were measured quantitatively. The quantitative data in the study revealed that the variable student-centered teaching had a relationship with low instructor bias and instructor inclusivity, meaning that students perceived the instructor to be inclusive and to have low bias toward them as a result of student-centered teaching.

The final part of inclusive classroom climate in the model includes supportive peer interactions. Students' supportive peer interactions that they cultivated in the online classroom environment through the virtual chat and in other online spaces outside of class created a sense of community for the students that they felt was facilitated by the instructors providing an "open" classroom environment. In Amar's class, students appreciated that they were allowed to choose their own groups and felt that they found support from peers in those spaces which contributed to their feelings that the course had an inclusive classroom climate.

Overall, student perceptions of inclusive instruction and inclusive classroom climate made students want to attend, participate, and engage in the courses. Women shared that they went to office hours more often in these two courses than in prior courses, felt comfortable asking questions in class, and felt engaged with the material.

Women's Socio-Emotional Outcomes

The final part of my conceptual framework includes the outcomes I examined: engineering self-efficacy, classroom sense of belonging, and desire to remain in the field. I have also included "sense of community" because this was something that students cultivated through their virtual and group interactions. Confidence and capability, as components of self-efficacy, are also included since they were important concepts that resulted from the qualitative analysis. Desire to remain in the field is essentially the disciplinary major and career decisions that students decided to make after they took their courses.

Sense of Community and Classroom Sense of Belonging.

The framework assumes that classroom climate contributes to women students' sense of a classroom community and classroom sense of belonging. Specific to the online environment, evidence suggested that the use of the "chat" function in Zoom allowed women to feel that they could seek help from their peers, which made them feel supported. In ChE 201, students were able to self-select into their groups that they worked with over the course of the semester. Many women selected groups they had worked with before, often choosing groups based on shared social identities. These groups provided "safe" and supportive environments that women described as helping their learning in the course. Black women especially discussed intentionally seeking groups that reflected their gender and race/ethnicity. The sense of community students achieved with some peers made them feel supported and helped some women combat negative feelings around abilities and skills in engineering.

Classroom sense of belonging which was a measure that focused on students' feelings of belonging in connection to peers was significant in the quantitative analysis. The regression analyses showed a significant, positive relationship between classroom comfort and classroom sense of belonging and the qualitative data indicated that students associated a sense of community with climate variations, particularly comfort. Therefore, it appeared that classroom sense of belonging was also related to the sense of community that students developed based on group interactions and virtual connections they made in the online classroom.

Engineering Self-Efficacy and Engineering Capability and Confidence.

The new conceptual framework also assumes that inclusive instruction and classroom climate contributes to engineering self-efficacy, capability, and confidence. In my quantitative analyses, engineering self-efficacy was found to be significant for women. It is likely that women's perceptions of inclusive instruction and an inclusive classroom climate were contributing to this change in self-efficacy. Engineering self-efficacy was also found to have a significant relationship with comfort although this was not able to be confirmed in the qualitative analysis. Further, the regression analyses also revealed a bi-directional significant positive relationship between classroom sense of belonging and engineering self-efficacy; students who felt a sense of classroom belonging also reported an increase in engineering self-efficacy in these courses at the end of the term. These results went in the inverse direction as well, with engineering self-efficacy having a positive significant relationship with classroom sense of belonging. Yet, the relationship between classroom sense of belonging and engineering self-efficacy was less clear in the qualitative data because I did not specifically ask students how sense of belonging might contribute to their sense of engineering self-efficacy.

Engineering capability and confidence are another part of this section that are closely related to engineering self-efficacy. Although my qualitative data did not directly present evidence of self-efficacy, it did provide evidence of students describing feeling more capable and confident in their engineering courses as a result of the inclusive instruction. Women, and some men, felt that their experience in the courses with the instruction made them feel more capable of being a chemical engineer and gave them confidence to be successful in future chemical engineering courses in the major.

Desire to Remain in the Field: Major and Career Decisions.

Most students in this study responded to the survey question about major intentions in the affirmative. This lack of variation in the data precluded statistical analysis of relationships among independent variables and this dependent variable. However, the qualitative analysis showed that most women and men in the group interviews discussed how the content of their course, the teaching practices the instructors utilized, and feeling that they were learning in the courses made them feel more confident and capable of having a desire to continue in chemical engineering. A small number of students had already lost interest in chemical engineering at the time of my study and did not have a desire to continue in the field after graduation. The extensive and rigid structure of curriculum requirements in many engineering fields make changing majors an unlikely choice for many students since it can add time to degree. For this reason, intent to continue in the major is a complex question, and an affirmative answer may only suggest the intention to complete rather than a real desire to continue in the field. For this reason, I chose the term "desire" rather than plans or intentions to capture the concept of "interest" that was suggested by my analysis. Further, although there were students who signaled that they had a desire to continue forward in the major, we cannot know if they will progress into the field of chemical engineering once they graduate.

Implications for Research

This new conceptual framework, informed by themes and patterns evident in my findings, allowed me to develop a set of propositions about the experiences of women in engineering classrooms with instruction and classroom interactions that should be explored in future studies. I discuss these propositions in the following section.

Propositions related to Social Identity and Academic Self-Confidence

Proposition 1

> *Negative interactions with both men peers and instructors in prior and other engineering courses create gendered experiences that contribute to women's perceptions of their academic self-confidence and their engineering abilities.*

Both women and men discussed past negative experiences with instructors upholding meritocratic values by being "tricky", grading on a curve, and attempting to "weed" out students. This is reflective of engineering culture that promotes beliefs of meritocracy which can lead to negative behaviors by instructors (Carter et al., 2019; Cech, 2013; Farrell et al., 2021) Women also reflected on instructors using their social role of instructor to act superior to students often using condescending tones, acting authoritatively, degrading students, and behaving in arrogant ways. For women, these behaviors affected their academic self-confidence not making them want to participate for fear of being viewed as inferior. Women also discussed shutting down and not wanting to participate in class because of negative behaviors of engineering instructors. Lester et al.'s (2016) study also found some similar findings revealing that negative treatment by instructors (singling women out or ignoring them) impacted women's engagement in the course.

Although my study was focused on instruction and what the instructors did in the classroom, the influence of peer interactions on women was unavoidable. Grunspan et al. (2016) and Robnett (2016) in their respective studies in STEM, found that men peers engaged in negative beliefs and biases about women. Tonso (1996), who observed engineering student interactions in teams, found that men peers in engineering engaged in negative behaviors toward women particularly dominating the teams, doubting women's abilities, and even making sexual remarks. In almost all of the interviews, women brought up negative treatment they experienced with men peers, especially in groups, in prior and other engineering courses. Men peers specifically engaged in patriarchal behaviors through gender microaggressions ignoring women and taking their ideas, mansplaining and using patronizing behaviors. Besides encountering gender microaggressions, Black women also encountered racial microaggressions by both White men and White women. The gender microaggressions that women encountered from their men peers decreased their participation in and outside the classroom. Women felt intimidated and this caused them to have low academic self-confidence. Other studies also show that women in engineering rate their skills lower than men (Ro & Loya, 2015) which may contribute to decreased self-confidence. Women in my study feared being perceived as "dumb" and "unintelligent", so they refrained from asking questions in class. They also encountered aspects of "imposter phenomenon" which made them doubt their abilities in engineering.

Propositions related to Inclusive Instruction

Proposition 2

Proposition 2a: Inclusive instruction (instructor empathy, care, and respect/collegiality) contributes to women's perceptions of an inclusive classroom climate.

Proposition 2b: Inclusive instruction (formative feedback and relevant content) contribute to women's engineering confidence and capability.

Women discussed how Roger and Amar were empathetic to their needs, taking time to get feedback on when to give them exams or release quizzes based on their other course exams and workload. Sometimes, Roger would poll the students to determine if he should remove a quiz or shift the date of a quiz based on student feedback due to work from their other engineering courses. Students appreciated being listened to and having a role in shaping the course.

Students appreciated the care that Amar and Roger showed them. The importance of care from instructors is also evident in the literature. Cokley and Chapman (2008) found that caring professors had a positive impact on African American students' academic self-concept. According to Lopez et al. (2019), the care from instructors that Latinos received in their science and engineering classrooms improved their experience in the classroom. Winterer et al. (2020)

also found that instructors that were caring contributed to Latinas' degree aspirations and academic performance. Women in this study appreciated how the instructors seemed to care about their learning. Women in my study also appreciated the one-on-one personal interactions they had with the instructors because they felt the instructors showed interest in getting to know them on a personal level. Women who attended office hours felt that the instructors were helpful, approachable, cared about their understanding of the material, and showed interest in the students beyond their academic performance. Women felt that these aspects of care contributed to an inclusive classroom climate.

Both Roger and Amar valued respect and collegiality. They did not appreciate instructors that talked down to students but valued mutual respect in the classroom with no structures in place that would make students feel beneath them. Amar and Roger wanted students to feel comfortable approaching them in and outside the classroom. Women felt that they were respected in class because of the way the instructors responded positively to student questions and comments and spoke to students as equals rather than speaking to students in condescending ways.

I found a link in the qualitative data between instructor's pedagogy and capability and confidence. Both women and men in Roger and Amar's courses felt that the pedagogy that the instructors engaged in such as being "overly" clear and presenting applicable examples helped them feel more confident and capable in learning the material. Students in Roger's course also felt that the quizzes, which provided immediate feedback and did not involve grading on a curve, made them feel more confident and capable in engineering. Because the students felt that they were learning, this increased both their confidence and capability. The STEM literature indicates that formative feedback may increase self-efficacy. Stewart et al. (2020) found that after women in physics received examination feedback, their gap in self-efficacy was reduced compared to their self-efficacy at the beginning of the course. Yet, their self-efficacy remained lower than men.

Students also appreciated the formative feedback that was given in Roger's course because they were able to determine their standing in the course and felt that they were able to solidify their learning as they progressed through the quizzes. Feeling that they were learning contributed to their perceptions of capability and confidence in the course and in the material. Students' perceptions of the relevance of the content in both courses and the way Roger applied the content to real world examples contributed to students also feeling capable and confident in the chemical engineering major and in the field.

Propositions related to Inclusive Classroom Climate

Proposition 3

> *Student-centered teaching, low instructor bias, and instructor inclusivity in the classroom contributes to women's perceptions of an inclusive classroom climate.*

My study revealed a quantitative relationship between instructor inclusivity, low instructor bias, and student-centered teaching which were significant and positive. Research on teaching methods such as active learning indicates a positive increase of self-efficacy, classroom social belonging, and performance outcomes (Ballen et al., 2017). Instructors that engage in inclusive teaching can potentially mediate feelings of exclusion marginalized students encounter in STEM (Dewsbury, 2020). The quantitative findings show that low instructor bias coupled with positive student-centered teaching contributes to an inclusive classroom climate.

Propositions related to Sense of Community and Classroom Sense of Belonging

Proposition 4

Proposition 4a: Supportive peer interactions contribute to a sense of community.

Proposition 4b: Perceptions of classroom climate as comfortable contributes to women's classroom sense of belonging.

My study revealed that the relationships that women made in their groups and in their classroom community contributed to them feeling that they belonged in the classroom. In Roger's course, the virtual chat made women feel that they were in a supportive community so they felt comfortable asking their peers any questions without fear of being judged. In one classroom interaction I witnessed, Roger discussed a recent flood that had impacted the state because a dam broke. A student in the course was from the area and posted in the chat that it was his hometown. This prompted many students to show sympathy and care to the student through kind words. Students in Roger's course also interacted virtually outside of the classroom using the GroupMe app to pose questions to each other and ask for help on understanding concepts. These virtual interactions made them feel more connected to the community in the course.

Students in Amar's course interacted in self-selected groups and for the most part, almost all women, except for one woman I spoke with, discussed how they enjoyed working with their group because of the support they encountered. Many women were also friends with their group members and felt comfortable asking them questions outside of the in-class group time. Women felt a sense of camaraderie with their groups, and it made them feel connected to the classroom community because they felt supported.

Women in both courses felt comfortable in the classroom environment because of the teaching practices the instructors utilized such as positive reinforcement and validation. Roger also incorporated aspects of humor which made the students more comfortable as well. As a result of these positive interactions that women experienced during class, they were more inclined to attend class, want to participate, and engage with the material in and outside of the classroom.

My quantitative analysis found that there was a positive relationship between comfort and sense of belonging. Harben and Bix (2020) studied a first-year packaging course and discovered a relationship between self-selected group interaction and an increase in sense of belonging. This is similar to the finding in my study that the supportive communities that women appeared to form through their small group interactions and in the virtual classroom appeared to contribute to this sense of comfort, which in turn increased their classroom sense of belonging. Although I found that the students cultivated a sense of community and sense of belonging through their groups, the literature appears mixed on the issue of self-selected groups compared to instructor-selected groups. Oakley et al. (2004) discuss how instructor-formed groups should place students together that have diverse abilities and should avoid isolating marginalized students. They argue that self-selected groups can lead to higher cases of plagiarism and can also affect student learning negatively. Yet, Harben and Bix (2020) found that self-selected groups promoted students' sense of belonging. This reveals that aspects of self-selected groups can improve students' sense of belonging, which may be the sense of connectedness and care that the students felt in the groups. Because students in my study discussed race and gender as primary reasons that they enjoyed working in their groups, instructors need to avoid isolating women and people of color (i.e., placing them in groups where they are the only one representing their race/gender) when forming groups so that feelings of connectedness can be facilitated.

Propositions related to Engineering Self-Efficacy, Engineering Capability and Confidence

Proposition 5

There is a bi-directional relationship between women's classroom sense of belonging and engineering self-efficacy.

The quantitative data revealed a positive relationship between classroom sense of belonging and engineering self-efficacy which was bi-directional. Verdín (2021), in her study on women in engineering, also found a relationship between competence/performance (which she explains is a construct of self-efficacy) and higher sense of belonging in the classroom and major. Johnson's (2012) study on women of color in STEM also found a positive relationship with academic self-confidence and sense of belonging. Students in both courses described how they had positive classroom sense of belonging because of their virtual classroom and group interactions which also contributed to their assessment of the classroom climate. The positive peer interactions that students have in a course may contribute to engineering self-efficacy.

Because the quantitative data revealed women's self-efficacy changed over time, it is likely that there is a relationship between inclusive instruction, classroom climate (and perhaps comfort in particular), sense of belonging, and engineering self-efficacy. All these relationships may be contributing to the increase in women's self-efficacy seen in the quantitative findings.

Propositions for Desire to Remain in the field: Disciplinary Major and Career Decisions

Proposition 6

Instruction influences women's desire to remain in the major and the field of engineering.

Women in the study discussed how the content of the courses, examples of application of engineering concepts, and feeling that they were learning the content contributed to their desire to remain in the field of chemical engineering. Riegle-Crumb et al. (2020) found that White women who indicated high satisfaction with their faculty interactions indicated a higher commitment to pursuing STEM as a career. Women in my study were able to draw connections between what they were learning in the classroom and their future careers in chemical engineering, which created excitement about those careers. Women also felt that the applicability of course content to the work they would do as engineers made them feel more prepared for a career in chemical engineering, which also promoted their desire to remain in chemical engineering.

Future Research

Aspects of engineering culture informed my study, but it was not a component that I thoroughly researched. While researchers have studied engineering culture's role in how students develop or change their beliefs and the negative cultural behaviors women experience, much less research has explored the effects of these cultural beliefs on women's engagement in engineering courses. Tonso's (1996) work studied how engineering cultural norms affected women in the engineering classroom while Carrigan et al. (2021) utilized case study interventions focused on researching bias to understand student's behaviors and their cultural beliefs and values. Cech's (2014) work has studied specific aspects of engineering culture such as changes in engineering students' public welfare concerns and the influences of meritocratic ideology on women (see Seron et al., 2018). Further studies could focus specifically on how engineering culture not only influences women's social identities but their participation and engagement in engineering courses as well.

Focusing on Instructors and their Pedagogies

Although my study included instructor interviews and placed a focus on the instructors and their adherence to and/or subversion of engineering culture, more studies of instructors are needed to further understand how engineering culture shapes their pedagogy. My findings suggest the importance of studying instructors' narratives to allow deeper and more complex analyses. Both qualitative and quantitative research methods could contribute to a larger scale study specifically on instructors and their own journeys through engineering and how it shapes their pedagogical choices. Pollard (2021) provides an example of a narrative study of engineering faculty members' pedagogical thinking and influences over time, but focused on how organizational contexts in engineering, rather than deeper cultural values in the field, shape instructors' thinking and behavior. Such studies would yield meaningful and complex understandings of how engineering instructors make their pedagogical choices and how engineering culture may or may not influence these decisions.

Further research should also be done on aspects of care in engineering classrooms and how instructors can promote empathy and respect/collegiality in their classrooms. Scholars like Riley et al. (2009) discuss how to center care in engineering classrooms, and research on how engineering instructors develop and create a caring environment in their classroom would be particularly helpful to engineering faculty. Specifically analyzing how an ethic of care affects a variety of socioemotional outcomes – and for different populations of students – should be a primary aim of such studies.

Studying Small Groups and Teams

Researchers such as Grunspan et al. (2016) have measured men peers' biases toward women while Sekaquaptewa (see LaCosse et al., 2016 and Sekaquaptewa, 2019) has conducted experiments on the effects of gender microaggressions on women by peers in academic STEM environments. Yet more research needs to be done to better understand why and how men peers develop their classroom behaviors and whether and how engineering culture intersects with other influences. It would be beneficial to study what men students notice about their group interactions with women and how they develop beliefs about engineers and about women as engineers. Specifically, are men able to recognize negative treatment that women experience in groups? How are they potentially influenced by behaviors from their engineering instructors? How is this behavior connected to gender and race? In my study, women of color indicated that all men regardless of race/ethnicity engaged in negative sexist behavior toward them so differences between men of color and White men would need to be explored as well.

There were limitations to my understanding of the group dynamics in my study since I was not able to "sit-in" on group interactions that students had or follow any students as they interacted with their classmates virtually. Further studies of women's group interactions in engineering, similar to that of Tonso (1996) and Henderson (2021) who studied cultural norms in engineering courses, could be beneficial to understanding how group experiences and perceptions of community contribute to a sense of belonging. Henderson's (2021) study of design teams, which included ethnographic observation of the dynamics on those teams as they related to eurocentrism, race, and gender, revealed how dominant Eurocentric epistemologies shaped students' participation in team-based learning settings thus also shaping their learning.

Centering Intersectionality

The experiences of women of color in engineering, particularly those of Black women and Latinas, should be further studied to understand how racism and sexism combine to affect women of color in engineering courses. Black women in my study all agreed that they encountered both racism and sexism. Nxumalo (2021), who recently discussed disrupting anti-Blackness in STEM through curriculum and pedagogy, defines anti-Blackness as a "framework for understanding the manifestation of dehumanizing and exclusionary systems and practices in multiple contexts for those collectively racialized as Black" (p. 228). McGee and Martin's

(2011) study of high-achieving Black mathematics and engineering undergraduate students found that they formed ways to manage racialized stereotypes targeting their Blackness and labelling them as less capable. More studies should interrogate how Black women are not only affected by their engineering experiences, but the forms of resistance they engage in to protect themselves from intersecting forms of oppression: anti-Blackness and sexism.

A subset of Latinas in my study discussed gendered experiences more than racialized experiences in their engineering courses. One Latina discussed connecting with others of her same race and appreciating diverse representation of engineers in her course, yet she did not discuss any issues with racism directed towards her. Another woman who identified as Black and Latinx discussed how many of her experiences in engineering were shaped by her Blackness. Latinos have a history of also engaging in anti-Blackness. Garcia-Louis and Cortes (2020) refer to this as anti-AfroLatinidad, defined as beliefs, practices, and behaviors in the Latino community that reflect an intentional rejection of AfroLatinidad and that exist not only through personal interactions but that are further promoted by society. This underscores the need to engage in further research to understand not only how anti-Blackness in engineering and other STEM disciplines operate but also how Latinas negotiate their race and gender and their potential relationship to whiteness.

Further Studies of Self-Efficacy in Engineering

The relationship between instruction and engineering self-efficacy needs to be further investigated in a variety of different engineering disciplines. Lord et al. (2019) showed that different disciplines have varying migration patterns in which some majors are able to retain certain populations than other majors within engineering. Findings from their study suggest the importance of conducting research on possible influences on women's self-efficacy across multiple disciplines in engineering.

In addition, the relationship with instruction and self-efficacy also warrants further investigation. Once again, disaggregating data by discipline, types of courses, and pedagogical strategies used in the classroom could be helpful to understand the connection between instruction and self-efficacy in engineering. A study could be conducted on a large quantitative scale but could also be done qualitatively specifically studying multiple courses where teaching practices are observed while women are interviewed to determine in which types of courses women's self-efficacy potentially changes or does not change.

Because the desire to remain in the field variable did not work quantitatively, future research may need to be conducted on students at the end of their first year in engineering coursework to understand how experiences in courses influence their desire to continue in the major or switch out. The connection of self-efficacy to desire to remain in the field is also an interesting relationship to further explore. Specifically, it would be important to ask: Under what conditions does engineering self-efficacy and/or sense of belonging contribute to a desire to remain in the field?

An area to further investigate is the disconnect between interest and capability and confidence, which in my study affected students' desires to persist in engineering. This may provide some insight into whether both self-efficacy and interest are needed to have a desire to continue in the major and field. Lent et al. (2008) discuss how their social cognitive career theory postulates that self-efficacy is a predictor of science and math interest, persistence, goals, and performance. But in my study, some students felt very capable and confident they could succeed in engineering -- feelings that are similar constructs to self-efficacy -- but were not interested in the subject and therefore did not want to continue in engineering. It may be that students need to be both interested and self-efficacious to persist in an engineering field. A recent study indicates that both academic self-efficacy and values may be necessary to support persistence. Lee et al. (2022) investigated the interactions between academic self-efficacy, values (interest, attainment, and utility values), and costs (opportunity, effort, and psychological costs). They found that students who had academic self-efficacy in engineering and valued engineering had higher engineering persistence whereas students who only felt self-efficacious or only valued engineering had lower persistence.

Another area that may be important to examine is psychological cost. Henderson et al. (in press) examined how psychological cost (cost of the effort needed to earn the degree) contributed to students' decisions to continue in the field of engineering. They found that students that persisted beyond the first year into their second year reported that they were less likely to continue pursuing a career in engineering after receiving their degree. They also found that minoritized students were less likely to indicate they would pursue a career in engineering after their second year. Henderson et al. conclude that student intentions to leave engineering after their first year may not only be because of a lack of interest, effort, and commitment but, rather, the underlying issue may be psychological cost. More research is needed to understand the potential relationships between engineering interest, psychological cost, and engineering self-efficacy.

Implications for Practice

The current study was conducted online so it is possible that what the instructors did and were able to do in the online environment may not be the same in a face-to-face classroom setting. Also, the responses that students gave might vary because the courses were delivered online and not in-person. Most studies of online education focus on academic performance and the differences and similarities between an online and face to face environment (e.g., Amro et al., 2015; McCarty et al., 2013; Yang et al., 2015); fewer focus specifically on instruction. This study thus contributes to the literature on online education in engineering and STEM fields in general, but it also may have implications to face-to-face learning: many of the linkages that I found between inclusive instruction and women's positive perceptions of the classroom environment confirm findings from existing research on inclusive teaching.

The instructors in this study incorporated many aspects of inclusive teaching and general teaching practices that students were receptive to. Chickering and Gamson (1987) argued that there are seven principles for good practice in teaching; these include encouraging contact between the instructor and students, developing reciprocity and cooperation among students, encouraging active learning, providing prompt feedback, emphasizing time on task, communicating high expectations, and respecting diverse ways of learning. Both Amar and Roger engaged in some of these practices, encouraging students to ask them questions during class and outside of class, providing students with clear expectations, engaging in active learning techniques (zoom polls, call and response, think-pair-shares), encouraging students to stay on task and to not fall behind by keeping up with assignments, recognizing that students needed the material communicated in different ways to comprehend it, and in Roger's case, providing immediate feedback through the quiz format in the course. Roger and Amar also engaged in certain inclusive teaching practices in the classroom which included practices such as being flexible by responding and adapting to students' needs and showing empathy, being transparent through their communication about expectations, proving the course material in a variety of modalities, allowing students to provide feedback on the learning environment, and dedicating time in class for students to ask questions about assignments.

My study focused on women's perceptions of instruction and their consequences for their socioemotional outcomes rather than the instructional modality used. Further study is needed to compare the impact of inclusive teaching in online and face-to-face courses, but the findings of this exploratory study, and particularly the proposed conceptual framework, can provide an initial step for studies of instruction across multiple delivery modes.

Currently many institutions are addressing DE&I and issues in and outside classroom contexts (Hayes et al., 2021), and STEM educators have engaged in these conversations in an effort to enhance student diversity and inclusion (Gonzales, et al., 2021). Some institutions have found ways to engage faculty in professional development to promote inclusive teaching in the classroom. Yet, getting instructors to engage in inclusive teaching can be a daunting task. Bathgate et al. (2019) surveyed STEM instructors about the barriers they encounter when engaging in evidence-based teaching practices (i.e., active learning, assessment, and inclusive teaching). She found that instructors indicated time was one of the primary barriers but also cited lack of resources, lack of confidence to engage in inclusive teaching, and lack of enjoyment. In my study, the instructors engaged in simple practices that humanized the learning experience thus making the classroom feel more inclusive to the students in this study. The instructors created an inclusive classroom by making students feel that they cared about them and their learning, showing empathy to students by listening to their needs to shape the course, and positively affirming students when they asked questions or responded to prompts in class. They treated students with respect and in a collegial manner, acknowledging the difficulty of the material, listening to student feedback regarding the workload, and treating students as equals.

Eschenbach et al. (2005) discuss integrating feminist pedagogy into the classroom through strategies such as collaborative learning and giving students an opportunity to be involved in class decisions. Both Roger and Amar, especially, used collaborative learning. Roger consistently gave ownership to students to determine the number of quizzes he disseminated and when to scale back. Amar sought feedback from his students as well, making changes to the course after the first few weeks when he received feedback that the students felt the homework problems and the in-class problems were too long. Participants in both courses expressed appreciation that they were being listened to and that their needs were being considered. Seeking student feedback and empowering students to have a role in the direction of the course dilutes power structures that exist within the engineering classroom.

Riley et al. (2009) argued that normalizing making mistakes is a form of liberatory pedagogy that can foster openness in engineering classrooms. In Roger's course, when he made mistakes, he acknowledged errors and showed his vulnerability in other ways. Participants in his course commented on these acknowledgements, saying it allowed them to feel it was ok for them to make mistakes as well and also made them feel better about their prospect of becoming an engineer.

Instructors need more information to understand that even slight adjustments in teaching practices can make a difference to women and marginalized students. To counter instructors' concerns that inclusive teaching and incorporating DE&I into courses are insurmountable tasks, instructors need evidence that simple and straightforward steps can help move in the direction toward inclusive and liberatory classrooms that meaningfully incorporate DE&I content.

There are ways to engage in this work through professional development for instructors. Felder et al. (2011) determined that a framework with five criteria was effective in designing engineering instructional development. These areas include having facilitators that have expertise in the subject, providing relevant content, offering choices in the way the information can be applied, engaging in action and reflection, and working in groups. Brent and Felder (2003) explain that a combination of workshops, seminars, and learning communities are important for engineering faculty development.

Many centers for teaching and learning are already engaged in this work but it may be beneficial to think of ways to reach the broader audience that they desire. Finelli and Millunchick (2013) developed the “Teaching Circle for Large Engineering Courses” which was a cohort-based program as a response to help instructors overcome perceived barriers to implementing student-centered teaching, and a similar approach could provide the community support needed to promote inclusive teaching. In these Teaching Circles, Finelli and Millunchick informed faculty about effective teaching practices, sought to influence their approaches to teaching, and provided tools for faculty to engage in effective teaching practices that could be utilized in a large classroom.

In developing the teaching circle, Finelli and Millunchick (2013) considered factors for adult motivation which included utilizing facilitators with expertise in engineering instruction, providing content that was relevant to the goals and interests of the participants, and giving participants a choice in how they could apply the concepts learned as well as put them into practice. Their assessment of the program’s impact found that instructors who were involved in the Teaching Circles changed their approach to teaching and engaged in different teaching behaviors. Teaching Circles like the one created by Finelli and Millunchick should be built into new faculty onboarding and orientation. Initially building a culture that values teaching and learning when new instructors arrive would be helpful since many are likely to have minimal teaching experience.

Using student stories to illuminate students' personal experiences in engineering could be an effective tool to encourage faculty to engage in behaviors that treat students in a positive way. The findings from this study could provide some examples, taken directly from engineering courses, which reveal how some simple practices can make a difference for women students. Many instructional development centers use case studies that present faculty with classroom scenarios, and such case studies of inclusive teaching could be developed to assist faculty in identifying practical ways to promote inclusivity. Such activities can promote dialogue amongst instructors, which could be beneficial for them to learn how to best engage with students through inclusive practices. Because many instructors are not prepared to be instructors, and even less to practice inclusive teaching, it is important to support them in developing evidence-based approaches to their teaching. Below I outline potential steps educators could utilize when engaging in professional development with instructors which are based on my findings and could potentially have a positive impact on students:

1. Present the research (instruction and the effects on women).
2. Use student stories and instructor stories to show the dynamics in the classroom and the effects on students.
3. Provide opportunities for instructors to reflect on these stories and their own personal thoughts about their instruction.
4. Provide simple steps to make changes.
    a. Follow the Golden Rule: Treat students as you would like to be treated; show them mutual respect
    b. Center care in your conversations and your classroom
    c. Validate students' questions and answers
    d. Ask students for feedback on timing of tests/quizzes and workload
    e. Acknowledge the material is hard and encourage students to not get discouraged
5. Engage in case study work: Scenarios provide instructors with opportunities to think about how they would respond to students in certain situations that would demonstrate inclusivity.

6. Provide resources/take-aways for instructors to continue thinking about as they take initial steps toward inclusive teaching.

These steps while also paired by other instructional development frameworks such as the one discussed by Brent and Felder (2003) may be helpful in developing effective modes of professional development for instructors in engineering. It is critical to begin conversations about inclusive teaching in a non-judgmental way. Instructors need to feel that they are in control of their classrooms and feel that small steps they take are manageable but also effective. Larger conversations around DE&I need to happen but that would be the next step beyond these initial tasks to move toward inclusive spaces.

Finelli and Millunchick's (2013) teaching circle discussion are very similar to what bell hooks (1994) discusses in her book *Teaching to Transgress*. They functioned differently though in that she created seminars for instructors to engage in "constructive confrontation" and "critical interrogation." Besides professional development geared toward teaching practices, there may also be a benefit to creating spaces for instructors to engage in conversations around pedagogy. In her book, hooks describes how fear played a large role in resistance from faculty to recognize how bias and white supremacy seeps into classrooms and for them to understand that classrooms are not politically neutral. As discovered in my discussion with Roger, even though he was quite aware of his biases and was taking an active approach to include DE&I into his classroom space, he was fearful of repercussions against him.

It could be beneficial to have instructors come together to discuss their fears while instructors like Roger, who have incorporated aspects of DE&I, can provide evidence of students' appreciation and the impact that such discussions can have on a class. hooks also shares that creating classrooms that function as a community can ensure that all voices are heard. hooks discusses how in her classrooms students journaled at the beginning of every class and then shared those reflections with another person. I believe that these types of activities where instructors can reflect on aspects of their teaching and discuss them with another instructor could be helpful as they navigate the potential fear they may have. Questions they respond to could include the following: Why do you teach? What do you like about teaching? What are your goals as a teacher? What is it about a teacher you liked in the past that you try to integrate into your own classroom? How do you recognize and accommodate different types of diversity in your classroom?

Department chairs have the potential to show that they value inclusive teaching practices by providing spaces for conversations around pedagogy. Conversations like this could occur at faculty meetings, retreats, or professional development seminars. They could also happen at a slow pace where only one question is presented at a time such as during a faculty meeting. These questions could continue to be addressed throughout the year where instructors reflect in writing and then share with a partner with a discussion to follow. Based on these conversations, instructors could share what they learned, and a list of instructor community practices could be created. It could be a list that is revisited at certain periods of time to remind instructors and to encourage self-accountability.

Centering an Ethic of Care

According to Riley et al. (2009), an ethic of care centers emotion, connection, and encourages a community-driven response in engineering decision making. Riley et al. (2009) argues that an ethic of care in engineering is needed to "approach problems from a perspective of responding to the needs of traditionally oppressed peoples and communities that is often absent" (p. 29). According to Noddings (2012) who coined the term "ethic of care" based on Carol

Gilligan's (1993) work on women's ways of formulating knowledge, care ethics postulates that "caring relation is ethically (morally) basic" and that relationships help shape the individual (p. 771). She further explains that caring is shaped by a person doing the caring and the other being 'cared for' and that in equal adult relations, these roles are exchanged regularly over time. Within unequal relations such as that between a teacher and a student, Noddings explains that both groups contribute to aspects of caring. She describes teachers as needing to be receptive to students, hearing and understanding their needs. And, when those needs are unable to be met, the teacher should maintain the caring relationship while they attempt to find ways to care for the student. Noddings explains that often teachers engage in "virtue care" making assumptions as to what students need and work hard to do that while not engaging in "relational care". She differentiates between assumed and expressed needs and argues that focusing on the latter is key to developing a care ethics-based teacher-student relationship. She argues that empathy toward students can help students develop moral education. One of the aspects of being a teacher-carer, according to Nodding, is not only being attentive to students but also allowing them to think out loud.

Noddings (2012) suggests instructors visit groups when they are dialoguing to identify areas that need clarification and to enter in dialogue with the students. She expresses how creating a relationship in the classroom built on care and trust allows for a better learning experience, an area in my study that I found to be true. Students, especially women, perceived the caring environment as contributing to their overall positive learning experience in the classroom. She explains that fostering cooperation and a non-competitive climate contributes to a caring climate. Nodding discusses that care ethics seeks to incorporate the common adage: Do unto others as you would have them to do you. The notion of mutual respect was important for instructors and students in my study. The instructors cultivated an environment that minimized power structures which was based on their own personal experiences in engineering. Students appreciated how they were respected as colleagues which contributed to them having a positive learning experience. Instructors can apply Noddings work to how they interact with students one on one and also while students are engaging in group work to combat any racial/gender microaggressions that students experience to support a more inclusive learning experience for students.

Conclusion

Solutions to the gender gap in STEM and particularly engineering have been guided by narrow approaches, attempting to discern why women are so profoundly underrepresented. Many universities have developed programmatic solutions developing women in engineering programs, residential floors, and other support programs targeted to those marginalized in STEM. Although these are wonderful solutions, they provide only a piece of the puzzle. For many women, these type of support programs can be instrumental for them to "survive" in engineering. As I set out to do this dissertation, my main question that I asked myself was how is engineering changing itself to create an inclusive environment for those marginalized in engineering, especially women? At what point is engineering engaging in self-reflective work to make the environment better for women instead of leaving the overarching work to extraneous support programs?

As I reflected on these questions, I sought to find evidence that could support my assumptions about the classroom environment and the effects on women. My study was able to support many of these assumptions while also providing directions for future research and identifying actionable ways to communicate the importance of making environments more inclusive. Supporting colleges, departments, and instructors in taking incremental steps to engage in practices that create an inclusive classroom can have a profound impact on women who are pursuing engineering and subsequent engineering careers. Changing the historical ways that engineering has treated its students can have an impact by both increasing women's enrollments but also keeping them in engineering. This is not to say that this is the only solution; I advocate for a multi-faceted solution that invests energy into support programs for women and marginalized students in engineering but also invests in educating engineering instructors, departments, and colleges about what they can do to support women and marginalized students. By maintaining silos and not working together, the goal of increasing and retaining women in engineering will be more difficult to solve.

My hope is that this research can be used to not only provide evidence but to create change. This research also does not go far enough. To truly create liberatory spaces, we must integrate aspects of social justice into classrooms. We must create spaces where students in engineering can have deep conversations about their role in society and how they can and will affect society in the work that they do, which are conversations that do not often happen in engineering. I call on us to first start with incremental change and hope that with incremental changes that create inclusive spaces, the next steps can be toward the inclusion of social justice aspects of the classroom, something similar to what Roger did in his classroom when having conversations around dams and their impacts on local communities. Students were appreciative of this discussion as it was not something that they had ever talked about in other classes. Even a small amount of class time that was dedicated to this issue appeared to have an impact on the students.

As I reflect on this study, I am hopeful about potential changes that can occur in engineering classrooms. As the world continues to change, I believe we will no longer have a choice but to integrate inclusive practices in engineering classrooms because of the social impact that engineers will be needed for as we confront a changing climate, an unstable political landscape, and a continued pandemic that has affected all facets of life. As these changes occur, women's voices should be listened to, appreciated, and heard as we move to create inclusive spaces in engineering classrooms.

Appendices

Appendix A

Instructor Recruitment Email

Dear Dr. ____,

My name is Selyna Beverly and I am currently a Ph.D. candidate in the Center for the Study of Postsecondary Higher Education (CSHPE) at the University of Michigan. I am writing to request your participation in my dissertation study regarding students' perceptions of instruction and its effects on students in the classroom, specifically their sense of belonging and self-efficacy. I was referred to you by [name omitted] (ChE advisor) as a potential instructor that engages in active learning in the classroom which will be helpful as my study centers on instruction.

This IRB approved study (HUM00163863) necessitates my unobtrusive observation of several of your class sessions during the winter semester which begins January 20, 2021. It will also require you to participate in two virtual interviews, one at the beginning and end of the semester. For in-person class sessions, I would make sure to comply with all university standards around COVID-19 procedures including social distancing and wearing a mask.

I will be specifically observing your pedagogical strategies and communication. I will ask you questions related to your teaching and your strategies for creating an environment in which all students are able to successfully engage and learn. You will receive compensation for your participation in this study. If you will consider participating, could you send me some of your available times for a virtual meeting to discuss further? If you have any questions, please contact me either through phone or email. I look forward to working with you and appreciate your consideration as I embark on important work to enhance student experiences in engineering classrooms.

Thank you,

Selyna Beverly

Appendix B

Student Recruitment Email

Dear Student,

My name is Selyna Beverly and I am a Ph.D. student studying Higher Education here at Michigan. I am conducting my dissertation study on how engineering students experience instruction in engineering courses with the goal of identifying ways to improve teaching and communication practices.

Your professor has agreed to allow me to conduct the study in his classroom, and I am inviting you to participate in the study as well. During the course, I will be observing your class sessions to understand how your professor teaches the course. To understand your experiences in the course, I am inviting you to participate in one or both study components:

- Student Perceptions of Instruction Surveys (one each at the beginning and end of the course)
- Small Group Interview

If you complete BOTH surveys, you will receive points toward your grade (see your syllabus) and will be entered in a drawing for one of five $100 gift cards. The first survey will take less than 5 minutes; the end-of-course survey will take approximately 15 minutes.

You may also sign up for a small group interview that will occur toward the end of the semester. If you participate, you will be compensated $30 for this 60-minute group discussion. I will make an announcement in class and will send an email after mid-term to request participants for the small group interviews.

Both surveys are located on canvas. The first survey is currently on canvas under the section labeled "Assignments". You can also go directly to the survey located at this link and then put a unique code into the survey quiz on canvas: https://umich.qualtrics.com/jfe/form/SV_8HxmrWxl4nhG9CZ

All the information I collect from you will be confidential; I will not use your name or identify you in any reports on the study findings.

If you have any questions, please feel free to contact me either through phone or email. I appreciate your consideration as I embark on my dissertation research with the goal of enhancing student learning experiences in engineering classrooms.

Thank you,

Selyna Beverly
spbeverl@umich.edu

Appendix C

Student Debrief Communication

Dear Student Participant,

Thank you for participating in my dissertation research study this semester. You may know that it is sometimes necessary in social science research not to tell the participants the purpose of a study because it might affect the results. If we tell participants the purpose of the study, they may deliberately do whatever it is they think we want them to do or they might deliberately act in the opposite direction to show us that we can't figure them out.
So that my study purposes did not affect your behavior in the classroom, I had to conceal the real purpose of the study until now. The study procedures you experienced in this study were approved by the U-M Institutional Review Board, and this debriefing letter is part of the post-study procedures approved by the IRB.

In the study, you completed a survey and may have participated in a group interview. Now I would like to tell you the purpose of this study.

I am particularly interested in how different levels of inclusive teaching practices affect student outcomes such as sense of belonging in college and engineering programs, and I am particularly interested in whether women and students of color experienced their engineering classrooms differently from men, who tend to be overrepresented in engineering classrooms.

Now that the study is over, I will adhere to my promise of confidentiality by concealing the identity of all participants in the study. I will do so by disguising the institutional, departmental, and program affiliations of instructors and students, as well as the courses that served as the site for the research as well. This will include information on the names of the course and other details such as department, course-level, type (lab, lecture), and year of data collection. I will also disguise personal characteristics that might identify you (i.e., age, year in college, academic major).

If you have any questions about this study or wish to withdraw from the study, please contact the PI or the Faculty Advisor:
Principal Investigator: Selyna Beverly
Email: spbeverl@umich.edu
Phone: [omitted]

Faculty Advisor: Lisa Lattuca
Email: llatt@umich.edu
Phone: [omitted]

If you have questions about your rights as a research participant, or wish to obtain information, ask questions or discuss any concerns about this study with someone other than the researcher(s), please contact the following:
University of Michigan
Health Sciences and Behavioral Sciences Institutional Review Board (IRB-HSBS)
2800 Plymouth Road
Study ID: HUM00163863 IRB: Health Sciences and Behavioral Sciences Date Approved: 6/24/2019
Building 520, Room 1169Ann Arbor, MI 48109-2800
Telephone: 734-936-0933 or toll free (866) 936-0933
Fax: 734-936-1852
E-mail: irbhsbs@umich.edu

Thank you!
Selyna Beverly
Doctoral Candidate
Center for the Study of Higher Education

Appendix D

Instructor Interview Protocols

Interview #1

1. What are your goals for this course?
2. What expectations do you have of your students?
   For example, what is your policy regarding attendance or extensions for required work?
   a. What do you hope students will learn about engineering and about introductory engineering concepts?
   b. For example, what kinds of instructional methods are you planning to use?
3. What kind of classroom environment do you try to create?
   a. What strategies and norms do you incorporate to create this type of environment?
   b. How, if at all, do your course evaluations influence your decisions about your teaching in this class or in others?
   c. How does where you are in your career currently influence your teaching style?
4. What qualities do you think engineering students need to develop to be successful in engineering?
   a. What are your thoughts regarding students having difficulty?
   b. Thinking about a student that may be having difficulty, some instructors feel it is their role to identify a problem and bring it to the student while other instructors feel it is the student's responsibility to ask for help.
5. Have you ever had to address an instance of discrimination or stereotyping in your classroom? If yes, please tell me what you did. If not, what do you think you would do?
6. What should I know about your course before I come in for the observations?
7. May I reach out to you again if I find I need clarification on the information you've provided?

Interview #2

Today I would like to hear about your experiences teaching the students in this course.

1. First, are there any goals or expectations that you had at the beginning of the term that did not turn out as expected?
2. How would you describe the online classroom environment? Can you provide some specific examples, both positive or negative if possible, that contribute to your assessment? How was teaching this course online similar to and different than an in-person course?
3. What were office hours like for you? How do you run your office hours? How would you describe the interactions with students? Were these interactions any different this term than the last time you taught this course (in person)?
4. I understand the college is trying to work on issues of diversity Are there ways that you try to make the classroom more welcoming and inclusive to all students?
5. **For Roger**[7]: I noticed that you included DE&I topics. What did you hope those topics would achieve? Do you think it made a difference based on previous courses?
6. How was the level of student engagement similar or different than when you have previously taught? Did you observe anything in particular about students' levels of engagement (less engaged or more engaged?)? Did you notice any patterns in engagement this term? PROBE: maybe certain groups participated more than others
7. Did you encounter any tension or uncomfortable moments in the classroom this semester? If so, can you explain? Probe: what did you do to diffuse the situation?
    a. Did you personally have any uncomfortable moments with a student(s)?
    b. **FOR Amar**[8]: Was the course format your idea (lecture first, ICPs after? If so, why did you decide to do it that way? How well did students interact in their groups. Did you notice any tensions in groups based on cultural or other differences? What, if any, steps did you take to assist students in their groups?
8. Do you see differences in student performance this term compared to the last time you taught this course?
9. Are there ways in which you think your social identity influenced the way you taught the course? For example, gender, race/ethnicity, first gen status.
10. Now that you are at the end of the course, and assuming you might teach this course again, is there anything that you would do differently, specifically regarding the classroom environment?
11. Is there anything I haven't asked you that you'd like me to know about what you tried to do or experienced this term?
12. Are you interested in a summary of the findings? I can get that to you once I have compiled the data.

[7] Pseudonym used to mask name
[8] Pseudonym used to mask name

Appendix E

Observation Protocol

Teaching Dimensions Observation Protocol (Hora & Ferrare, 2013) adapted by S. Beverly

	Evidence and Overall Assessment (i.e., note time spent, timepoints, overall engagement)
Lecture	
Lecture: Premade visuals (e.g., PowerPoint)	
Lecture: Handmade visuals	
Lecture: Demonstration	
Lecture: Interactive (i.e., 2+ questions posed)	
Small group work	
Desk work	
Pedagogical strategies	
Movement	

Humor	
Illustration/anecdote	
Organizational marker	
Emphasizes topics	
Assessments	
Student–teacher interactions	
Rhetorical questions	
Display questions (e.g., What is X?)	
Comprehension questions (e.g., Do you understand?)	
Student comprehension question	
Student response to question	
Type of cognitive engagement	
Articulate	
Recall/memorize information	
Problem solving	

Making connections to world	
Instructional technology	
Chalkboard	
Overhead projector	
PowerPoint	
Clickers	
Digital tablet	
Movies or simulations	

Appendix F

Observation Protocol Sample Notes during Class Session

3/29 52 20 cams. 16 women

[redacted]

Teaching Dimensions Observation Protocol (Hora & Ferrare, 2013) adapted by S. Beverly

	Evidence and Overall Assessment (i.e., note time spent, timepoints, overall engagement)
Lecture	Some info about points & quizzes; discusses cheating (student puts clapping icon) Talks about honor code - avoid cheating site; if you are having trouble, come talk to me, I hope everyone passes this class. If you aren't come talk to me
Lecture: Premade visuals (e.g., PowerPoint)	Pic of coffee on record player; Liquid draining out of sink
Lecture: Handmade visuals	Crosses off parts of equation in red, circles in blue & red arrows
Lecture: Demonstration	
Lecture: Interactive (i.e., 2+ questions posed)	
Small group work	
Desk work	
Pedagogical strategies	
Movement	hand motions - up & down, tip of the pot, spinning motion, hands up & down, above, flat emphatic hands when explaining pulling down, coffee cup up/down
Humor	Someone yawns & he laughs - ~~this~~ I'm going to try to make this interesting & talks about record player - is it called hipster? - Students respond
Illustration/anecdote	which is very important when bldg airplane wings
Organizational marker	Starts class going over what ~~will be discu~~ they will be doing, kind of finished that section but want to go back. 2:13 goes over what they have covered and intros new section - now going to do E1 - it's a mix of certain topics. That concludes E1
Emphasizes topics	Boundary conditions always tricky, other one is tricky
Assessments	None of you look very happy today (students respond about their thermo quizzes) (2x) Is that good? - Students nod, everybody done with that? Alright, I'm going to keep going
Student–teacher interactions	

Student asks question in chat & someone answers
Finally sees chat & responds
Thanks student for responding to his lack of naming section

3/29

[redacted]

answers question in chat - Great question!

You all are very smart ppl so you can handle this.

gets another question but asks for clarification so she unmutes

Rhetorical questions	Another question: Great question! Black man - asks for clarification says thanks - he says thank u.
Display questions (e.g., What is X?)	
Comprehension questions (e.g., Do you understand?)	any questions before we leave this section? any question's on that? Questions about that?
Student comprehension question	
Student response to question	
Type of cognitive engagement	
Articulate	
Recall/memorize information	
Problem solving	2:07 - Reviews what they ~~went over~~ did last time; draws graph w/ curve; shows numbers on spreadsheet 2:13 2:28 - derivation
Making connections to world	Drop in piece of paper on coffee compared to draining sink - explaining rotation uses ~~these~~ examples to explain different concepts in this section.
Instructional technology	
Chalkboard	
Overhead projector	
PowerPoint	
~~Clickers~~ Zoom poll	① pics - choose which is rotational; goes over answer - says it's not intuitive - I would have guessed both
Digital tablet	
Movies or simulations	

Can't figure out Greek letter - so asks students & they give him answer
Stops at some point to say sorry! I got a text message for my son's contacts
I'm like that dog that sees a squirrel

Appendix G

Examples of Weekly Summaries Incorporating Observation Data

Roger's course: ChE 101
Jan 20-22

The instructor started off by sharing his screen (the syllabus). He went onto the course management platform to walk students through different parts of the syllabus. He injected a lot of different humor throughout the class as well as personal anecdotes. He made a joke about his handwriting and swearing in class which prompted the other students to add on to the joke in the chat. He used an anecdote about flossing telling the student that when your dentist tells you to floss, you should just like he was telling them to review the concepts. As he was going over the syllabus he emphasized that he wanted students to have equal access to the material. He also discussed how the problems given will incorporate DE&I. He also emphasized how learning happens best and went over teaching and learning strategies.

Once he transitioned to PowerPoint slides, he had pictures and diagrams and drew arrows, notes, circles, underlined, using red. He kept asking the students if there were any questions. At one point, there was a question and he said "I can explain that more, I did go over that pretty quickly". At another point another woman had a question and he responded saying "great question!".

Students were using the chat function quite a bit and he was not really paying attention to the chat until later in the class when he was beginning to teach. He stopped and finally realized that students had noticed a problem with him skipping a part on a slide so he went back and exclaimed "thank you!" after he realized his mistake.

Used PowerPoint with diagrams using red to draw errors, underline and circle. He keeps a tone of humor throughout the class also apologizing when he has difficulty with his tech. He doesn't always see the questions in the chat so the GSI jumps in to let him know. He takes a minute to explain often saying "good question!" Great question! And also asking if others have questions. He asked his students to keep their cameras on so he could see their faces if they looked quizzical. At one point he asked them if they understood. He got a few questions from students and took time to answer and then asked if he could move on and the student said yes. He did pose a question to the class at one point and students shook their heads to answer. He also did a couple problems with the students walking them through the problems. He also repeated some questions that students asked. Problem was about a pool. Often he asks if he is going to fast or he says "sound good?". He is assessing the students learning as he goes. He also constantly emphasizes that he is trying to get the students ready for life and trying to help him learn. He also uses hand motions when he speaks at times.

Students also interacted with each other in the chat answering each other's questions.

Amar's course: ChE 201
Jan 19-Jan 21
Was very organized with technology, very comfortable in remote format. Amar kept emphasizing that he was very passionate about reaction engineering; he talked about his experience in the course and how it really had an impact on him. He emphasized that students should ask for help as there were many resources presented in the course. He also signaled his willingness to be flexible and to help students as well. He was encouraging as well indicating that the problems are not challenging and that they do not want to increase the amount of time students need to spend on the course. Seemed very understanding of different situations students may be in. He was very quick to respond to student questions in the chat. Sometimes, saying the students name, always repeating the question. Every time he would say "great question!" "good question!". He also went over the diversity statement and said he wants an inclusive classroom. He said he wants everyone to feel comfortable in the virtual classroom and if they don't feel comfortable, to speak to him personally so he could figure something out.

He used PowerPoint throughout his lecture and at one point connected a concept to the real world. He discussed how ammonia is used for fertilizer that makes half of the world's food and 1% of energy and discussed application-environmental, chemicals, energy, drug delay.

His slides were clear and organized and he interacted with the slides by drawing on them, underlining, circling, drawing pictures. He had some animations, but they didn't work. At one point he displayed some rhetorical questions and then went forward by explaining the answers. At another point he posed two questions and the students responded in the chat. He exclaimed "very good!" when he saw the answers were correct.

Appendix H

Group Interview Protocol

INTRODUCTION:

Thank you very much for agreeing to share your classroom experiences with your instructor and peers in the current engineering course. I am a doctoral candidate working on my dissertation and am interested in learning about the engineering classroom environment. I am interested in the full range of experiences you have had in the classroom, whether positive or negative. Let me assure you that our conversation today is strictly confidential. I will not link what you say to you by name or in any way that would allow others to identify you. I also ask that any information presented by participants in this session stays within the group and is not discussed beyond this group. Additionally, if I ask you a question that you are not comfortable answering, please let me know. I don't anticipate asking you anything that will make you uncomfortable --but IF I do, feel free to say that you'd rather not answer. Also, it would be very helpful if you left your cameras on and kept yourself unmuted. Is there anything you would like me to clarify before we begin?

First, I'd like to ask about your experiences in the course, with your instructor and your peers.

1. Tell me about your instructor. What kind of classroom environment would you say he tries to create? What specific actions or words or behaviors would you point to that support your characterization? For example, you said the instructor tried to create a [INSERT PARTICIPANTS' WORDS] environment. How did he do that?
2. How clear were the instructor's expectations for assignments?
    a. For Roger's CLASS: Your instructor did not have exams in this course, how did this impact your experience in this course?
3. Did you interact with your instructor personally? How? For example, did you go to virtual office hours? If so, how did those interactions go for you?
    a. Can you identify any positive or negative interactions with the instructor?
4. Is there anything that the instructor~~s~~ did in this course that interfered with your learning?
5. How did the zoom environment influence your experience in the course? How did you think the environment affected your learning in the class? How did it compare to a face-to-face engineering course?
6. What could the instructor have done to make your experience in this course better?

Now let's talk about your participation in class.

7. First, did you attend class regularly? Why or why not?
8. When you attended did you participate in class in some way? If so, how did you do that? If not, why didn't you participate? Probe: did you ask questions, answer questions, etc.

9. How would you characterize the overall participation in the class?
10. Do you think everyone participates equally in the course? Is that any different in other engineering courses? Why do you think some people participate more than others? It seems that some students are more comfortable using the chat. Why do you think that is?
11. How does your participation in this course compare to face-to-face courses?
12. FOR AMAR'S COURSE ONLY: Now let's focus on your experience in your groups. I understand that you met in groups after lecture to do ICPs. I'd like to hear about how your groups worked. First, would you say your groups ran well? [Just get a sense of their overall assessment, then ask for specifics in next questions.]
    a. Let's start with some of the positive experiences you had working with other students in this course. Can you give me some examples of positive interactions with your group members?
    b. How about negative interactions you had in your groups in this class?
    c. Do you think some people were treated better or worse than others in your groups? If so, how were they treated and why do you think that happened?
    d. Do you find the group work helpful for your learning? How does it help or hinder your learning?
    e. How does your experience in this course compare to other group experiences in past classes?
13. FOR ROGER's COURSE ONLY: Let's focus on your experience in the break-out rooms
    a. When you were in the break-out rooms did the conversations feel comfortable to you, why or why not?
    b. Did anything that your peers did in the course or in the break-out rooms interfere with your learning?
    c. Does it feel different than a group discussion in a face-to-face engineering course?
14. Do you think your social identity or identities influenced how your classmates or instructor treated you? If so, in what way?
15. How have past experiences in navigating your social identity in other classrooms been different or the same? Does the zoom classroom environment make a difference? If so, how?
    a. FOR AMAR's CLASS: Does working in groups with the same people make a difference? In what way?
16. I just have one last question: In thinking about your overall experience in this course, did it make you feel any more or less capable of succeeding in your engineering major? Why? Is this different or the same than other courses you have taken (the feeling that you can or can't succeed in engineering)?

Appendix I

Factor Loadings from Pilot Data

Appendix Table 1

Dependent and Independent Variable Scale Items and Loadings by Factor

Items	α
Dependent Variables	
Engineering Self-Concept	.90
I am just not good at engineering.	
I get good grades in engineering.	
I learn engineering quickly.	
I have always believed that engineering is one of my best subjects.	
In my engineering class, I understand even the most difficult work.	
Sense of Belonging	.94
I know I can turn to my peers in this course for academic assistance.	
My classmates and I share relevant class-related information with each other.	
I would be comfortable talking to my classmates about any challenges I was experiencing in this course.	
I have friends in this class who I feel I could count on if needed.	
My classmates and I are supportive of one another.	
I have peers in this course who I study or do classwork with.	
I feel like my peers in this course respect me.	
I feel like I am a valued member of this classroom community.	
Independent Variables	
Academic Engagement	.82
I asked questions in class.	
I discussed grades or assignments with the instructor.	
I attended my instructor's office hours.	
I participated in class discussions.	
I tutored other students in this class.	
I reviewed class material before it was covered.	
I attended review or help sessions to enhance understanding of the content of the course.	
I studied or did homework with other students from the class.	
Instructional Methods	.91
Set clear expectations for performance	
Convey the same material in multiple ways (in writing, diagrams, orally, etc.)	
Explain new concepts by linking them to what students already know	
Use examples, cases, or metaphors to explain concepts	
Answer questions or gone over material until students "got it"	
Provide encouragement to students through actions, words, or norms in class	
Demonstrate a willingness to work with students	
Provide examples that represented different backgrounds, identities, and culture	
Instructor Inclusivity	.91
I felt comfortable asking questions in class.	
I felt that my instructor believed I was capable of succeeding in this course.	
I felt included during classroom activities.	

In general my interactions with the instructor were positive.	
The instructor treated everyone in class fairly.	
The instructor showed respect for students.	
The teaching assistant/graduate assistant showed respect for students.	
The instructor fostered a classroom environment where students could express their opinions or perspectives	
Classroom Inclusivity	.78
The instructor welcomed feedback from students and used it to improve the course.	
The instructor used stereotypes based on race in the class	
The instructor used gender stereotypes in class.	
The instructor used stereotypes based on socioeconomic class in the course.	
The instructor supported students working through conflict or tensions.	
The instructor developed a supportive environment for learning for all students.	
The instructor developed an encouraging environment for learning.	
The instructor cares about my learning.	
The teaching assistant/graduate assistant cares about my learning.	
Classroom Climate	.84
I feel comfortable sharing my own perspectives and experiences in class	
I feel comfortable contributing to class discussions.	
I have been singled out in class because of my identity (such as race/ethnicity, gender, sexual orientation, disability status, religious affiliation, etc.)	
I feel I have to work harder than other students to be perceived as a good student	
In class, I have heard my peers express stereotypes based on race.	
In class, I have heard my peers express gender stereotypes.	
In class, I have heard my peers express stereotypes based on socioeconomic class.	

Appendix J

Pre-Survey

Demographic Information

The following questions ask about your demographic information.

1. What is your gender?
   Male (1)
   Female (2)
   Non-Binary (3)

2. Please select one:
   I am a U.S. Citizen (1)
   I am a Permanent Resident (2)
   I am an International Student (3)
   I prefer not to answer (4)

3. If you are an international student or permanent resident, please provide your country of origin and ethnicity
   Country of origin ________________________
   Ethnicity ______________________________

4. What is your race/ethnicity?
   African American/Black (non-Hispanic) (1)
   American Indian/Native American (2)
   Asian American/Pacific Islander (3)
   European American/White (non-Hispanic) (4)
   Hispanic American/Latino/a (5)
   Other (6) ___________________

5. What is the highest level of formal schooling completed by either of your parent(s)/guardian(s)?
   Did not finish high school (1)

High school graduate/GED (2)
Attended college but did not receive a degree (3)
Vocational/technical certificate or diploma (4)
Associate or other 2-year degree (5)
Bachelor's or other 4-year degree (6)
Master's degree (M.A., M.S., M.B.A., etc.) (7)
Doctoral degree (Ph.D., J.D., M.D., etc.) (8)
Unknown/Not applicable (9)

Engineering self-efficacy

6. Think about studying engineering: To what extent do you agree with the following statements?
   Strongly Disagree (1) Disagree (2) Neither Agree nor Disagree (3) Agree (4) Strongly Agree (5)

I can succeed in an engineering major
I can complete the math requirements for most engineering majors
I can succeed in an engineering major while not having to give up participation in my outside interests
I can excel in an engineering major during the current academic year
I can succeed (earn either an A or B) in an advanced physics course
I can complete any engineering degree at this institution
I can succeed (earn either an A or B) in an advanced math course
I can complete the physics requirements for most engineering majors
I can succeed (earn either an A or B) in an advanced engineering course
I can complete the chemistry requirements for most engineering majors

Appendix K

Post-Survey

The following questions ask about your demographic information.

1. What is your gender?
   Male (1)
   Female (2)
   Non-Binary (3)

2. Please select one:
   I am a U.S. Citizen (1)
   I am a Permanent Resident (2)
   I am an International Student (3)
   I prefer not to answer (4)

3. If you are an international student or permanent resident, please provide your country of origin and ethnicity
   Country of origin ___________________________
   Ethnicity _________________________________

4. What is your race/ethnicity?
   African American/Black (non-Hispanic) (1)
   American Indian/Native American (2)
   Asian American/Pacific Islander (3)
   European American/White (non-Hispanic) (4)
   Hispanic American/Latino/a (5)
   Other (6) _____________________

5. What is the highest level of formal schooling completed by either of your parent(s)/guardian(s)?
   Did not finish high school (1)
   High school graduate/GED (2)
   Attended college but did not receive a degree (3)

Vocational/technical certificate or diploma (4)
Associate or other 2-year degree (5)
Bachelor's or other 4-year degree (6)
Master's degree (M.A., M.S., M.B.A., etc.) (7)
Doctoral degree (Ph.D., J.D., M.D., etc.) (8)
Unknown/Not applicable (9)

6. Are you a Chemical Engineering Major?
Yes (1)
No (2)

(skip-logic) If no: What major have you declared?
Aerospace Engineering (1)
Biomedical Engineering (2)
Chemical Engineering (3)
Civil Engineering (4)
Climate and Meteorology (5)
Computer Engineering (6)
Computer Science (7)
Data Science (8)
Electrical Engineering (9)
Engineering Physics (10)
Environmental Engineering (11)
Industrial and Operations Engineering (12)
Materials Science and Engineering (13)
Mechanical Engineering (14)
Naval Architecture and Marine Engineering (15)
Nuclear Engineering and Radiological Sciences (16)
Space Science and Engineering (17)
Undeclared (18)
Other (please specify)___________________ (19)

7. How likely are you to change your major before graduation?
Very likely (1)
Somewhat likely (2)
Likely (3)
Not likely (4)
Very unlikely (5)
Don't Know yet/Not applicable (6)

8. What class year level are you?
   1st year (1)
   2nd year (2)
   3rd year (3)
   4th year (4)
   5th year (5)
   6th year (6)

Course Experiences

Professor's Teaching Methods, Professor and Classroom Inclusivity
The following questions ask about your Professors' teaching methods and your interactions with the Professor.

9. In this course, how often did your Professor:
   Never (1) Rarely (2) Sometimes (3) Often (4) Very Often (5)

   Set clear expectations for performance
   Convey the same material in multiple ways (in writing, diagrams, orally, etc.)
   Explain new concepts by linking them to what students already know
   Use examples, cases, or metaphors to explain concepts
   Answer questions or gone over material until students "got it"
   Provide encouragement to students through actions, words, or norms in class
   Demonstrate a willingness to work with students
   Provide examples that represented different backgrounds, identities, and culture

10. Please indicate the extent to which you agree or disagree with each of the following statements:
    Strongly Disagree (1) Disagree (2) Neither Agree nor Disagree (3) Agree (4) Strongly Agree (5)

    I felt comfortable asking questions in class.
    I felt that my Professor believed I was capable of succeeding in this course.
    I felt included during classroom activities.
    In general my interactions with the Professor were positive.
    The Professor treated everyone in class fairly.
    The Professor showed respect for students.

The Professor fostered a classroom environment where students could express their opinions or perspectives.

The Professor welcomed feedback from students and used it to improve the course.
The Professor used stereotypes based on race in the class
The Professor used gender stereotypes in class.
The Professor used stereotypes based on socioeconomic class in the course.
The Professor supported students working through conflict or tensions.
The Professor developed a supportive environment for learning for all students.
The Professor developed an encouraging environment for learning.
The Professor cares about my learning.

11. Please feel free to explain any of your responses to questions 11 and 12.

Sense of Belonging

12. Please indicate the extent to which you agree or disagree with each of the following statements:
Strongly Disagree (1) Disagree (2) Neither Agree nor Disagree (3) Agree (4) Strongly Agree (5)

I know I can turn to my peers in this course for academic assistance.
My classmates and I share relevant class-related information with each other.
I would be comfortable talking to my classmates about any challenges I was experiencing in this course.
I have friends in this class who I feel I could count on if needed.
My classmates and I are supportive of one another.
I feel like other students in this course respect me.
I feel like I am a valued member of this classroom community.
When studying for this course, my classmates and I often tried to explain the course material to one another.
In this course, students often worked together to solve problems during class time.
I often worked with other students from this course outside of class time to complete the course assignments.
When studying for this course, I often set aside time to discuss the course material with other students from the course.

13. Please feel free to explain any of your responses about interactions with your classmates.

Classroom Climate

14. Please indicate the extent to which you agree or disagree with each of the following statements about your experiences in this course.
Strongly Disagree (1) Disagree (2) Neither Agree nor Disagree (3) Agree (4) Strongly Agree (5)

I feel comfortable sharing my own perspectives and experiences in this class
I feel comfortable contributing to class discussions.
I have been singled out in this class because of my identity (such as race/ethnicity, gender, sexual orientation, disability status, religious affiliation, etc.)
I feel I have to work harder than other students to be perceived as a good student
In this class, I have heard my peers express stereotypes based on race.
In this class, I have heard my peers express gender stereotypes.
In this class, I have heard my peers express stereotypes based on socioeconomic class.

15. Please feel free to explain any of your responses.

Engineering self-efficacy

16. Think about studying engineering: To what extent do you agree with the following statements?
Strongly Disagree (1) Disagree (2) Neither Agree nor Disagree (3) Agree (4) Strongly Agree (5)

I can succeed in an engineering major
I can complete the math requirements for most engineering majors
I can succeed in an engineering major while not having to give up participation in my outside interests
I can excel in an engineering major during the current academic year
I can succeed (earn either an A or B) in an advanced physics course
I can complete any engineering degree at this institution
I can succeed (earn either an A or B) in an advanced math course
I can complete the physics requirements for most engineering majors
I can succeed (earn either an A or B) in an advanced engineering course
I can complete the chemistry requirements for most engineering majors

17. Please feel free to explain any of your responses.

18. Is there anything else you would like to tell me about your experiences with your peers and the Professor in this course?

Appendix L

Appendix Table 2

Factor Analysis of Classroom Inclusivity

Item	Factor Loading	
	1	2
Factor 3: Learning-Centered Environment		
The instructor welcomed feedback from students and used it to improve the course	0.76	
The instructor supported students working through conflict or tensions	0.71	
The instructor developed a supportive environment for learning of all students	0.92	
The instructor developed an encouraging environment for learning	0.92	
The instructor cares about my learning	0.88	
Factor 4: Instructor Bias		
The instructor used stereotypes based on race in the class		0.99
The instructor used gender stereotypes in class		0.99
The instructor used stereotypes based on socioeconomic class in the course		0.97
Eigenvalue	3.55	2.9
Percentage of variance	71%	97%
Construct reliability	0.89	0.98

Appendix M

Appendix Table 3

Factor Analysis of Classroom Climate Items

Item	Factor Loading	
	1	2
Factor 6: Classroom Bias		
I have been singled out in this class because of my identity (such as race/ethnicity, gender, sexual orientation, disability status, religious affiliation, etc.)	0.84	
I feel I have to work harder than other students to be perceived as a good student	0.59	
In this class, I have heard my peers express stereotypes based on race.	0.95	
In this class, I have heard my peers express gender stereotypes.	0.88	
In this class, I have heard my peers express stereotypes based on socioeconomic class.	0.95	
Factor 7: Classroom Comfort		
I feel comfortable sharing my own perspectives and experiences in this class		0.93
I feel comfortable contributing to class discussions.		0.93
Eigenvalue	3.63	1.71
Percentage of variance	73%	86%
Construct reliability	0.9	0.83

Appendix N

Codebook

Student Codes	Definition	Example
INSTRUCTOR		
Student-Centered Teaching	Instructor engaging in teaching methods (this can include zoom polls, pausing for questions, qualifying answers, connecting concepts to the real world, or other pedagogical practices)	Would probably just say his jokes. We used to just joke around a lot. So it makes it a little more fun than I think just... Or than a professor, just lecturing and just talking about the content. He also goes over examples, so that helps with, I guess easing my... Or some of my worries about some of the quizzes, yeah.
Positive DEI Perception	Student discusses liking the DEI activity or describes it.	I really wish we did more DEI problems and discussions
Helpful Instructor	Student describes instructor as being helpful either one on one or in class	Can I also add, I feel like professors [name omitted] technical literacy, using Zoom and stuff really helps as well, because I've had other professors that can't figure out how to open the chat, so that's a lost course of participation, you'd have to get up the nerve to unmute to ask, so I think that's also very helpful.
Instructor Inclusivity	Instructor engages in inclusive practices	I feel like he's super welcoming as a teacher. He doesn't really put down people's questions, which I feel is sometimes the case in engineering, but he's pretty good about it. And yeah, he's pretty responsive to us I feel like, which is pretty cool.
Behaviors	Instructor engaging in certain behaviors related to their personalities (saying hi to students, making jokes, expressing enthusiasm or excitement)	I'd say also with the exam, even just before grades came out and he was like, "It was a hard test. If you feel like you did bad, I promise it wasn't you." And even if you did bad. He's reassuring even if you score poorly on the exams.

Past Instructor Behaviors	Student discusses past behavior of an instructor whether positive or negative	Yeah, I would say of the few engineering professors I've had so far, he's definitely one of the most accommodating, especially now that everything is so different, he and the rest of the teaching staff have really been open to our input and how we want to see this course shaped, so it's been really refreshing to see that, especially now.
Instructor Caring	Student alludes to or specifically describes the instructor or teaching team caring for the students and/or caring about their learning	I think he really cares about what we say that he took the time to poll us and asked about what days worked best for us. He gives us that little break during class, understands that we need a break from that long of the class, so I really appreciate that. I think he really genuinely cares that we are understanding the material.
Course Tools	Concrete tools used in class such as PowerPoint/slides	Yeah, I think it's pretty professional. He makes sure everything is done on time. You pretty much expect all the lecture links to be sent out the same day beforehand, and then, with office hours, I like how it's structured, too, with different breakout groups for each type of question.
Instructor Race	Discussion of instructor's race	I think he's a very comforting face, at least because, for me, all of my professors in the past have been White, specifically for chem, and this is the first semester where they haven't been White. It's just a different sense of comfort.
Class Format	How the instructor lays out the class format which includes deadlines, structure of the class, exams	The only thing is that I didn't realize how many more deadlines were going to come at the end of the semester, and I feel like this is the busiest time for all my other classes, so that kind of came as a shock because it started off pretty easy with the amount of work that was happening, and then it piled up at the end, which is not my favorite, but I guess it just happens that way.
Instructor Response to Student Feedback	Instructor's response to evaluations	He took our feedback and changed the deadlines
Classroom Environment	Instructor making the environment a positive experience for the student	I feel like he's super welcoming as a teacher. He doesn't really put down people's questions, which I feel is sometimes the case in engineering, but he's pretty good about it. And yeah, he's pretty responsive to us I feel like, which is pretty cool.
Negative Classroom Environment	Instructor making the environment a negative experience for the student	Student describes environment as unwelcoming or not feeling comfortable

Inclusive Classroom Environment	Student specifically discusses an inclusive environment	I think it's been an inclusive environment. Yeah, I can't think of an event where I felt out of place.
Welcoming Classroom Environment	Student specifically discusses a welcoming environment	He's a very welcoming, and I think he's doing the best he can, given the circumstances, and making it very welcoming, questions, and facilitating that group work the best way possible.
Clear Expectations	Instructor's expectations were clear	I thought they were pretty clear. He has the spreadsheet where all the assignments are listed. So that's pretty clear in what we are expected to do. I think the only thing that could make it a little clearer is it would be nice if we could know when the quizzes would be released, but other than that, it's pretty straightforward to do.
Unclear Expectations	Instructor's expectations were not clear	Student explains that the expectations are not clear
Expectations both Clear and Unclear	The student does not specifically describe the expectations as being clear or not clear but rather indicates that they were a little bit of both	I feel like the homeworks are super variable in how hard they are and how much time we need to put into it, like one each week can change a ton. So, I feel like that's lacking clarity. But he's super consistent with when they're assigned and when they're due, which is pretty clear.
Personal Interaction between student-instructor	Personal interaction between student and instructor (office hours, before or after class, during break, or outside of class) This can also include emails or any virtual communication; can include communication with teaching team	I'm recovering from a transplant, and I was in this class last year when I first found out I had kidney failure, and he's very welcoming to that change, and if something comes up, he usually communicates pretty fast and works with me on stuff.
Positive student-instructor interaction	Student describes a positive interaction with the instructor	Well, he didn't know exactly of what it was, he often has to look stuff up, which I get because they can't memorize everything of the course, but he said he'd address it the next lecture and he did. So, it was nice to just be like, "Oh, my question was remembered, even though they said, couldn't answer it then."
Negative student-instructor interaction	Student describes a negative interaction with the instructor	I've talked to so many people that are like, "I don't ask questions during office hours because I'm afraid. This other person is so far ahead of me that they're just

		going to be annoyed by it or something like that." But in person, I never felt that way. I didn't know I could feel that way until we went online.
Student-instructor Classroom Interaction	Interaction with instructor during class (asking or answering questions and the instructor's response)	With his polls, I think he's pretty good at trying to be somewhat inclusive, but I do think that in this class, from my experience compared to last semester, there's been a lot less questions asked. Usually, there's people in the chat that will just add in questions and, sometimes, I don't think that's happening as much this semester. Maybe that's just an observation from me but I think he's still pretty inclusive and I think he tries to engage, especially if you come in a bit early.
Positive student-instructor interaction in classroom	Student describes a positive interaction with the instructor during class	It doesn't ever feel like he's rushing to get through content or rushing to get through answers.
Negative student-instructor interaction in classroom	Student describes a negative interaction with instructor during class	He made me feel out of place and awkward.
Learning Obstruction by Instructor	Student indicates that something the instructor did interfered with their learning or an aspect of the class (structure of the course)	He makes a lot of mistakes on the slide
Learning Enhanced by Instructor	Student indicates that they learned a lot or felt that the instructor helped them learn or that the instructor created a learning environment	He said he's even wanted to, I guess, lighten the pressure on us in this course because of the pandemic.
Critique of Instructor	Student discusses things they liked or didn't like about the instructor or the course	Most of the problems are with the homework, either Polymath or like the Wolfram problems that just take time, but you don't get anything out of them.
CLASSROOM ENVIRONMENT		

General Assessment	Student gives a general assessment of classroom environment including discussion about class organization (lecture, group work, etc.)	I think participation is as normal as it will be in the class. I think people are asking the necessary questions, especially when I'm personally extremely confused, some will ask a great clarifying question.
Class Content	Student describes the content of class being personal to the student or another student they interacted with	I don't think the people are the same, but it's, I guess the same thing that's happening is more concentrated to a certain... Certain people who participate.
Self-Conscious in Class	Student either describes their own issues with being self-conscious in class or describes how others could be self-conscious	I don't want my question to come off as a dumb question
No Self-Conscious	Student describes not being self-conscious in class or describes others not being self-conscious	I usually participate just by chat questions or like answering questions or asking my friend's private messages to, my camera's on maybe 40% of the time, like not too much. But yeah, I'm not really afraid to type a question in the chat, even if I think it's a stupid question.
Not Interrupting	Student describes not wanting to interrupt the instructor or other students	This might just be a me thing, but it's also sometimes if you're talking, I feel like I'm interrupting the lecture.
Zoom	Discussion of Zoom environment	The biggest thing has been with office hours. It's just been really frustrating to not be able to show my work to them because I have to go from square one instead of being able to jump off from the work I have just because I don't have device where I can share my screen to show my work. I have it on paper.
Zoom Chat	Student describes others using the chat or explains how they use the chat function of zoom	It's like almost a little more anonymous, like your name is there, but it's not like you projecting your voice and everyone whipping their heads around to look at you in the lecture hall.
Zoom Positive	Positive experiences with zoom	It was a lot easier for me to attend a Zoom class than it would've been to attend an in-person class. So, that was helpful for learning,
Zoom Negative	Negative experiences with zoom	I think the hardest part about Zoom is just, for anyone, sitting on Zoom all day, like the Zoom fatigue of it.

Zoom Learning Improved	Student discusses how their learning was better because of zoom	For me personally, I think I enjoy Zoom a lot more. I think it's just less intimidating, I guess, even to just ask questions because I could privately message the professor.
Zoom Learning Decreased	Student discusses how it was harder to learn on zoom	Overall, Zoom learning has been much harder.
Zoom Participation More	Student describes that they participate more on zoom (this includes them attending office hours)	I attend office hours more than I ever did in person
Zoom Participation Less	Student describes that they participate less on zoom	In comparison to in-person classes, I definitely participate less, just because you don't get that participation of talking with your seat neighbor and working on stuff like that.
Face to Face General	General discussion experience in face-to-face courses	I feel like if I remember correctly from being in-person, I would never raise my hand. And like there was sometimes a certain person that would always ask questions and it's just like, oh my God, stop talking,
Face to Face Better Learning	Student discusses how their learning is better in face to face	That's also what I'm thinking about here is like, "I'm going to have this class with him and I might not get another one, but I really wish I could have had that kind of energy, that environment, that atmosphere. That would make me infinitely more successful, I feel.
Face to Face Worse Learning	Student discusses how their learning is worse in face to face	Learning in-person is just not as great as being online
No Difference in Learning between Zoom and Face to Face	Student indicates that they don't feel there is any difference in their **learning** between face to face and zoom and its impact on the class environment	The set-up in general is similar because with in-person they would still use the iPad and go over projector and same lecture notes, so the only difference, really, is its online, and then you do lose that connection where you can people on your homework groups or for office hour stuff.
No Difference in Participation between Zoom and Face to Face	Student indicates that they don't feel there is any difference in their **participation** between face to face and zoom and its impact on the class environment	It's been pretty similar other than the fact that, if we're doing polls in an in-person lecture, I might turn to the person next to me and say "Hey, what are you thinking?" That's literally about it.

General Class Attendance	Student describes their attendance generally; they may say 50/50	I attend semi-regularly as well. If I have, I don't know. With online school, I'll make plans during the day without much care to missing classes because I can just watch it later.
Regular Class Attendance	Student attends class regularly	Yeah, I attend synchronously. I like to do that
Irregular Class Attendance	Student does not attend class regularly	Yeah, I try to watch synchronously, but, for me, I have ADHD, so it's easier for me to watch asynchronously so I can pause the recording whenever I zone out, which happens quite often
Personal Participation	Student describes their general participation in class	I don't really ask questions that often, but if he asks a general question, like, "Does everyone understand?" or something, then I'll make a signifying motion.
Personal Participation High	Student's participation in class is high	Compared to other online courses, I definitely participate in this class more.
Personal Participation Low	Student's participation in class is low	I'd say I have minimal participation. I usually just answer Zoom poll problems. I'll ask a question if I really need to, but I usually just ask someone around me or wait for discussion to be in a smaller setting because I don't particularly like asking questions in the large class setting.
Description of Low Participation	Student describes why they do not participate in class	I do the Zoom polls. Otherwise, I don't participate as I mentioned before. Unless I have a really good question and I know that it's not stupid, then I'll ask it, but otherwise, I don't participate intentionally.
Description of High Participation	Student describes why they participate in class	I don't think I've ever answered a question in class until we were in a Zoom environment. I'm usually not someone to ever raise my hand. And I feel like a lot more confident in saying something in the chat or unmuting really quick and getting that feedback on my thinking or asking a question if I don't understand.
Participation: Ask/Answer Questions	Student shares that they ask or answer questions during class	When I'm there live, I participate by keeping my camera on and I use the chat.

Participation in In-Class Activity	Student describes participating in an in-class activity (surveys, zoom polls, breakout rooms)	Unless I have a really good question and I know that it's not stupid, then I'll ask it, but otherwise, I don't participate intentionally.
Virtual Peer Interaction	Student describes virtual peer interaction	I felt very alone in this class. I'm a senior, so I'm graduating. This is like a junior class. I took things in the weird order, so I don't really know anyone. Other than seeing people at office hours, I pretty much am alone. That's very difficult with the Zoom environment.
Face to Face Peer Interaction	Student describes face to face peer interaction	I feel like it's harder to ask the small questions to your neighbor or just quickly walk up to him at the end of class and ask a question. I feel like that's the biggest thing I'm missing out on.
No Peer Interaction	Student describes not having any peer interaction	When we're face-to-face, I just answer the clicker questions, fill in my notes, ask my partner, person who's sitting next to me my questions I never ask the professors. I just don't have the person sitting next to me anymore. I just go to office hours.
Classroom Participation	Student's assessment of their peers classroom participation as a whole	There's two or three people who participate and it's just like only them, like the one girl who talks on the video. One girl has her video on during class. We all know who it is. It's like that top five people and then everyone else is just chilling.
Participation Comparison to Face to Face	Student's comparison of their or other's participation in class to a face-to-face classroom	I honestly think it's different than an in-person environment. Because like in an in-person environment, people are still coughing, shuffling around, there's general background noise, but in a Zoom meeting, it goes from being dead silent, like you speaking and then everyone's focus is on you
GROUP WORK		
General Assessment of Group Work	General assessment of the group work in class	I think we talked about the dams for the first one, and it was an interesting conversation, like we were talking about how we weren't really aware of these issues. But, after a while, we ran out of things to talk about, so we were just sitting there, waiting for the breakout rooms to end.
Zoom Impact on Group Work	Discussion of zoom impact on group work	If you're in-person it's super awkward to not, if you're like in a group of four people, it's like super weird to just not say anything, like no one

		would ever do that. But it's not weird on Zoom. But most people just don't talk.
Current Positive Experiences of Group Work	Current positive experiences working in groups in this course	I think we are respectful to each other. I know that I can ask a question and if someone knows the answer, they will take the time to explain it to me, which I appreciate.
Positive Group Work (Race)	Positive experiences working in groups based on race	Discussing the factor of race when speaking about group work
Positive Group Work (Gender)	Positive experiences working in groups based on gender	I enjoy working with other women in my group.
Current Negative Experiences of Group Work	Current negative experiences working in groups in this course	The equation one, we were either all lost or we all just didn't want to say something and have it be completely wrong. I've had that in most Zoom classes, I'll have breakout rooms, nobody will talk the entire time and it's extremely uncomfortable.
Negative Group Work (Race)	Negative experiences working in groups based on race	Discussing race as being a problem in group setting
Negative Group Work (Gender)	Negative experiences working in groups based on gender	He's definitely made me feel uncomfortable on behalf of my friend, if that makes sense. He was saying an answer, and she was corroborating it, and he just kept talking over her and saying his answer was right, and they actually had the same answer. So, there was no need for that
Treatment in Groups	Description of how students treated each other in their groups	And it really does help that we knew everyone going into it. Like our other class, it's like another class where we didn't get to pick our groups. That's where I've had some poor interactions, I guess you'd say. But being able to pick your groups really did help.
Group Work and Learning	Discussion of group work and learning	It definitely does help in my experience, just like forcing you to use the knowledge right after you learn it instead of just drifting away to Neverland or whatever
Group Work Helping Learning	Discussion of group work helping their learning	And I'm also in a group that I'm very comfortable with and we all know each other and feel comfortable being confused together. So, that's good.

Group Work Hindering Learning	Discussion of group work hindering their learning	Most of the time, the ICPs are too long to be able to explain the things that the people in your group don't understand,
Other Groups (Past or in another Class)	Experiences with other groups in other courses	The people who understand the quickest and the people who take the longest to understand is a way bigger gap in my group this class than normal.
Positive Experiences in Other Groups	Positive experiences with other groups in other courses	I've had similar people in my group all through chemical engineering, so it's the same people, I know what to expect, we work well together.
Negative Experiences in Other Groups	Negative experiences with other groups in other courses	If you are taking that facilitator role and you ask a question and then no one responds, that's a little frustrating because then you can't carry on a conversation with yourself, so that kind of interferes with learning.
Group Work with Same People	Group work with the same people	The group that I've been working with, we've worked together for the past two semesters, so we were really comfortable with each other.
Group Work with Same People (Race)	Group work with the same people in regard to race	And then as far as groups, I don't think any specific people or instances show otherwise. Maybe because of my identity, I've found the group with a similar identity
Group Work with Same People (Gender)	Group work with the same people in regard to gender	I already had all the girls' numbers that I'm in a group with, and we text all the time. It's not just about ICPs. So, it's just very fluid. Any time I have a question about the class at all, they're responsive.
Caring about Group	Expressing that they do not want to let their group down, caring about the success of their group, expressing responsibility	Outside of the falling behind thing, I just really don't want to let my group down, so I try to go regularly because I don't want to not be there and then it's like one less brain helping to figure out the problem.
Finding Support from Group	Student describes finding support and/or collaboration in the group	It's also an easier forum to ask the stupid questions, quote-unquote. I feel so much better about asking really basic questions to my ICP group than I would putting it in a Zoom chat or asking in class.
Not Finding Support from Group	Student describes not finding support and/or collaboration in the group	I think a big part of it for me, this semester is just not been having my support group that's taking the class with me and my normal people who I study with.

SOCIAL IDENTITY		
General Discussion of Race in Engineering	General discussion of race in the context of engineering (class, or outside of class)	My first design team, I was with three other males and so they're all White and so it wasn't intimidating,
General Discussion of Gender in Engineering	General discussion of gender in the context of engineering (class, or outside of class)	I would say it's just not second-guessing women. The girls in the groups work but not the guys, or guys reading over your paragraphs and making comments but not doing that to everyone else in the group.
General Discussion of Other Identity in Engineering	Student describes another social identity that is salient to them (first gen, religion, disability, etc.)	I don't really know about the women in engineering, how that affects me, but I've been struggling with a chronic illness this past year or so, and so it's definitely been much easier on Zoom, because I can stand up, walk around, get water whenever I need it.
No Impact of Social Identity in Engineering	Student expresses no issues with any social identities	I have not noticed being treated any differently because of my social identities.
Social Identity is Dominant in Engineering	Student indicates that they have a predominant social identity, so they are not marginalized	I would say I have never really had an issue with that, or that might be just because my specific social identity doesn't deal with a lot of mistreatment or issues, it's never really been a problem.
Current Treatment by Instructor (Race)	Student's perception of treatment in the current course by instructors based on race	I have indigenous heritage, and this is the first class I've ever heard anything about indigenous people mentioned and how he talked about when we did the DEI thing,
Current Treatment by Instructor (Gender)	Treatment in the current course by instructors based on gender	Student describes feeling targeted in class based on gender by instructor
Current Treatment by Instructor (Other Social Identity)	Treatment in the current course by instructors based on a different social identity	Student describes feeling targeted in class based on different social identity besides race or gender
Current Treatment by Students (Race)	Student's perception of treatment in the current course by students based on race	Student discusses feeling discriminated against based on their race

Current Treatment by Students (Gender)	Treatment in the current course by students based on gender	I would say in office hours in the past there have been some male counterparts who just encourage making us feel stupid as women.
Current Treatment by Students (Other Social Identity)	Treatment in the current course by students based on a different social identity	Student describes treatment based on a different social identities
Past Treatment based on Social Identity (General)	Student describes past treatment based on their social identity but are not explicitly clear as to what identity that is	I haven't really felt listened to. Something that I complain about a lot is when I ask a very specific and detailed question and then I get a response that isn't even really relevant to what I said
Past Treatment by Instructors (Race)	Treatment in past courses by instructors based on race	Student describes being treated by instructor based on race
Past Treatment by Instructors (Gender)	Treatment in past courses by instructors based on gender	Student describes being treated by instructor based on gender
Past Treatment by Instructors (Other Social Identity)	Treatment in past courses by instructors based on a different social identity	Student describes being treated by instructor based on a different social identity
Past Treatment by Students (Race)	Treatment in past courses by students based on race	It's more like small assumptions made just because of my social identity. Like, I would sometimes get the answer to something really quickly and I'd be helping some friends out and they'd be like, oh wow, you got that really quickly. Like you must be really smart or small comments like that. It's kind of like I can't tell sometimes whether it's because that's because they see me as smart as a person or if it's like they're assuming that I am because I'm Asian
Past Treatment by Students (Gender)	Treatment in past courses by students based on gender	But there definitely have been some group projects for this one class I took last year where I felt that I was the only girl in this group. And they gave me certain tasks that would be more stereotypical, like making the slide show and making it aesthetic.

Past Treatment by Students (Other Social Identity)	Treatment in past courses by students based on a different social identity	Student describes treatment by students based on social identity
Treatment by Students in another Course (Race)	Treatment in another course by students based on race	Navigating other settings, such as another class I'm in right now, where our groups are assigned, has caused a more negative experience just because I'm not able to work with people with the same or similar social identities
Treatment by Students in another Course (Gender)	Treatment in another course by students based on gender	In terms of all of those classes, I think the main experience I've had is just people not listening to me, especially when it comes to men not listening to the women of the group
Treatment by Students in another Course (Other Social Identity)	Treatment in another course by students based on another social identity	Student describes treatment in another course by other students about a different social identity
Race-Based Treatment on Zoom	Treatment based on race relative to the zoom environment	And so, like in a positive way, maybe you're just not as aware of the identities of the people around you, but also in a negative way, you're not as aware of the people's identities around you
Gender-Based Treatment on Zoom	Treatment based on gender relative to the zoom environment	It's worse online because you don't have that body language. You can't really read other people as well, as if you're face-to-face,
Social Identity Disappears on Zoom	Discussion of how social identity disappears on zoom	I feel like it's easier online because you don't have to be as immersed in that culture, which tends to make me feel pretty bad.
Social Identity Same on Zoom and Face to Face	Student explains that social identity experiences on zoom and in person are the same for them.	I felt like it's been about the same, like mostly good experience and occasionally get something, like some sort of mansplainer or whatever. But, yeah, it's been about the same as in-person.
Treatment by Students in Face to Face (Gender)	Discussion of gender in face to face	I haven't felt terribly affected by anyone not respecting me. I also just appreciate that ChemE, as an engineering major, does have a lot of women, so that's always encouraging to see when we're in class. I actually can't really see that over Zoom, but it's nice to see in person.

Treatment by Students in Face to Face (Race)	Discussion of race in face to face	My race, so my being Asian and being a first-generation college student. Just because a lot of students aren't, there aren't very many in Michigan, so that's a big thing. That's a lot more noticeable in person
Treatment by Students in Face to Face (Other Social Identity)	Discussion of other social identity in face to face	And also, I think also just being online, it's also not as obvious in some ways, like if it was in person, if I had my laptop out, I have a big first gen sticker on my laptop.
Capability/Confidence		
Instructor Impact	Instructors impact on student's capability/confidence	I like that he's honest about how well he understands the information. If you think something's hard, he'll tell us that he thinks it's hard, which makes me feel better if I don't understand what's happening. And that gives me more motivation, like, okay, I can learn it,
Current Course High Capability in Engineering	Feeling more capable of succeeding in chemical engineering	After this class, I would say significantly more confident, just because of the style of learning, and I feel like, in this class, I really had a better understanding with most topics, and that just gave me a lot more confidence.
Current Course Low Capability in Engineering	Feeling less capable of succeeding in chemical engineering	I think no, just because this course has been really hard and I think it put me down a little bit, but I know it's just one course. But yeah, I think for me, it's just this course was not the best one.
Past Course High Capability in Engineering	Feeling more capable in chemical engineering in past courses	Prof. [name omitted] makes mistakes so it makes me feel that I can make mistakes too
Past Course Low Capability in Engineering	Feeling less capable in chemical engineering in past courses	Sometimes it's like really small things that make your confidence lower. And that's like one of the reasons you don't want to like participate as much, if that makes sense.
Ambivalence of Capability	Student does not feel more or less capable	Personally, I feel pretty much the same because I feel like we're in the home stretch here, one year left.
No Desire to Continue in ChE	The course influencing student to not want to pursue CHE	I feel more capable, less interested.

Desire to Continue in ChE	The course influencing student to want to pursue CHE	Yeah, apart from other lab or design classes, compared to the other core or ChemE classes, I'd say this one made me feel more connected to the material.
Format Influencing Capability	Student discusses how the format (structure) of the class impacted their capability	I think online format in general can kind of give you that feeling of being incapable because it's so much harder to learn in that environment. I think he has minimized that, with the way he has setup the course.
CONTEXT		
Students Location while Taking Course	Students' discussion of home life or their situation while they are taking the class (e.g., roommates, bad internet, work, etc.)	I think it is really nice that I can just roll out of bed. I feel like because I'm more well-rested, then I'm able to pay attention, but also, because it's not in person, I'm usually distracted by my roommates and what they're doing, and because no one can see me.
Sense of Belonging	Student describes feeling connected to classroom or how they feel that they belong in the classroom environment	I feel really lucky that we do have that connection, because I think that if we didn't, it would take a lot longer to get it done, because I feel like we're all okay. Just be like, "Okay, this is this," it allows for us to go a lot faster, which is really nice
ENGINEERING CULTURE		
Engineering Culture	Discussion of aspects of engineering culture whether positive or negative	I don't feel judged by my group members, which I think is a good thing and that's not always true in engineering groups, so I feel thankful for that

Instructor Interview Codes	**Definition**	**Example**
INSTRUCTOR		
Student-Centered Teaching	Instructor engaging in teaching methods (such as zoom polls, or certain pedagogical practices)	I assume that I'll be using polling and raise hand features but that'll be another set of things that I have to develop,

DE&I in Course	incorporation of DEI into classroom	I wanted them to realize that the world was not fair and that they had to be cognizant of that, and they had to realize they were a part of it, they were a part of that unfairness.
Hopes for Learning	Instructor describes what they hope students will learn based on their teaching in the course	So, I am very focused on those fundamental concepts, cementing them in, and not so much as when I teach design, which is a senior-level course, and requires group projects for almost all the grading, focusing on how they interact with each other then.
Enjoyment with Teaching	Discuss how they enjoy teaching the material	I love teaching sophomores and juniors because they give you respect, saying hey, you know more about this subject. Please tell us. We want to do well.
Learning Outcomes and Objectives	Instructor describes learning objectives or learning outcomes for course	I hope they gain knowledge in the whatever, 60 different areas that I picked out, or more specifically in five different broad areas that I've organized all the material into.
Desire for What Students Learn	Instructor describes what they personally want students to learn and gain from the course	I really don't want to have exams so I wanted to feel less like the students are constantly trying to guess what's going to be on the exam and guess what they need to know, and just more tell them exactly what they need to know and give them enough problems so that they can practice
Instructor Beliefs about what Skills Engineers Need	Engineering skills instructor believes student need	Third is you have to learn how to communicate and collaborate, so you have to be able to tell other people what you're thinking and then listen to what they're thinking so you come up with some, I guess, conglomerate.
Past Experience with Instructor Influenced Teaching	Instructor describes a past personal experience with an instructor, with a course that made them want to teach a certain way or got them excited about the material they are teaching	This was my favorite course in undergrad. I think it, to some extent, set me on a path of this is what I want to do with ... With my life maybe is too over the top, but with my career, for sure.
Behaviors in Course	Instructor engaging in certain behaviors (saying hi to students, making jokes)	I change my pace. I do a lot of things that relied on me interacting with the students, and this is going to be more like an electronic interaction that is going to be programmed into the computer, essentially a lot of that interaction

Instructors Beliefs about Helping Students	Instructors' discussion on how they help students that are struggling	I try to model that by I don't talk down to them. I don't say well, you're all stupid and really can't understand this. I'm much smarter than you because I have more degrees. I would never say anything like that.
Tool	Tools used in class	I would love to have Canvas, and I'm going to try to work on this. Automatically ping students. In other words, after week one, have them ping them hey, you have a total of 75 points. You are ahead of schedule to pass this course, and if you keep up on the rate, you'll be done with the course three weeks before it's done.
Class format	How the instructor lays out the class (class format)	I love the format; I love how we or how I structured the material into separate categories and then did quizzes
Instructor Response to Student Feedback	Instructor's assessment of class based on questions or evaluations including how they changed the class based on student feedback	I always go through the evaluations as written and tabulated, so I read every single one of the written evaluations and I make notes, usually for next year on things to change, things to keep.
Classroom Environment	Instructor's ways of making the environment a certain way	I change my pace. I do a lot of things that relied on me interacting with the students, and this is going to be more like an electronic interaction that is going to be programmed into the computer,
Inclusive Environment	Instructor describes making environment inclusive	Yeah, in terms of inclusion, I think that the things that usually I try to do that are related to that, are one, kind of be responsive to people that do have requests. Because some of the things, we adjust. People have external things, how do we adjust assignments, how do we adjust deadlines, and those types of things? More on a basis of, what do people need?
Welcoming Environment	Instructor describes making environment welcoming	To create a learning environment. Typically, I talk a little bit about ... Usually, just when I'm going over the syllabus a bit about what my expectations are for how students behave during class and how I expect them to treat one another and how they should expect me to treat them
Expectations	Instructor's discussions of expectations	I thought maybe they'd have their videos on more. I think when they went to the in-class problems maybe they did. There was still participation in the chat, questions during class.

Personal Interaction with Students	Instructor's interaction with students (office hours, before or after class, during break, or outside of class)	I can scan through and sort who's got the lowest and I can send them emails but that's, again, a lot of work and I might have my GSIs do that. I might just have them sort the points every day and give them cutoffs on where they should be.
Positive Interaction with Students	Positive interactions with students either in class or out of class	So, I liked the office hours a lot more this year than last year. So yeah, I guess I would say that's an advantage. I felt like the office hours were more ... they were much more heavily attended, it was learning more
Negative Interaction with Students	Negative interaction with students either in class or out of class	Student describes a negative interaction "He made me feel uncomfortable when I went to ask him for help"
Classroom Interaction with Students	Instructor's interaction with students during class (instructor's response to student questions/answers)	It was very difficult not having them all have the cameras on. So, I felt like the environment was very nice among a select group of students, which also happens in a classroom, right? You get the ones that are going to be vocal and the ones that are not, and most of them are just along for the ride.
Positive Classroom Interaction	Positive interaction in class	I felt like the environment was very nice among a select group of students,
Negative Classroom Interaction	Negative interaction in class	But basically the thought for me is that everybody that's in the class belongs in the class, and it's unacceptable for any student or me as the professor to say or do anything that makes people feel discriminated against or makes people feel unwelcome in the classroom environment.
CLASSROOM ENVIRONMENT		
General Assessment of Classroom Environment	General assessment of classroom environment including discussion about the layout during class time	Those final problems, they took the GSIs, a lot of time to do, and I didn't hold back out of the 10, I tried to give three easy ones, four medium ones and two or three hard ones. And the hard ones are tough, if they get them, they deserve an A.
Zoom Environment	Discussion of Zoom environment	It was this strange dichotomy of it felt more engaging and less engaging. It felt more engaging in that I could talk directly to this smaller group of students, but it felt less engaging in that I don't know what any of them really look like because their pictures are too small.

Positive Zoom Environment	Positive experiences with zoom	Instructor says something like "I loved zoom; it was so much fun to teach with it"
Zoom Chat in Class	Instructor describes others using the chat or explains how they use the chat function of zoom	I think the one nice thing about the chat function over in-person is that it allows me more control over the flow, a little bit. Because one, there's not a person asking a question, so usually I can word it a little more succinctly, especially if I have time to see it and then think about it a little bit.
Negative Zoom Environment	Negative experiences with zoom	It was just this flat screen in front of me that I could click on and click off and it was like, in some ways I didn't have any students this term. And that's kind of sad, that makes me sad.
Face to Face Course Discussion	Discussion of face-to-face courses	A lot of the in-person response is not necessarily even to ask questions, it's just everybody looks confused, so I say something again.
Classroom Participation	Instructor's assessment of classroom participation as a whole	I think they were good participation in in-class problems, they were attending pretty regularly. I think probably the attendance, based on Zoom poll problems and stuff, was fractionally as good as last year.
Participation Comparison to face to face	Instructor's comparison to participation in zoom versus face-to-face classroom	I think there are a lot of similarities, it's like you just lose some of the ... I think you're still conveying the information basically correctly. It's just more the feedback from me is through a computer rather than face-to-face, which is just different.
GROUP WORK		
General Assessment of Group Work	General assessment of the group work in class	I think that was something I wasn't sure how to monitor well, like in terms of the interpersonal things when they go into breakout rooms. I didn't hear anything from it, but I also wasn't going ... I couldn't see anything.
SOCIAL IDENTITY		
General Discussion of Social Identity	General discussion of a social identity	So that's something that I think is something I've been working on, I suppose. To not imagine, oh okay. When I was in this class, how did I want to be taught? What is good for the entirety of the thing?

Race in Engineering	General discussion of race in the context of engineering (class, or outside of class)	I just think I have it easy because, and of course I lose one of my strengths being on Zoom because I'm 6'1", so that in a classroom, I'm not a small, I only weigh 160 or 170, so I'm not a big hulking person but I am tall which is an advantage in teaching at least based on the literature, which you would know this better than me. I don't have an accent, I'm White, I'm a man, and I forget the fifth thing
Gender in Engineering	General discussion of gender in the context of engineering (class, or outside of class)	In the core courses, everybody's trying to show up everybody else and show the professor that they're the smartest, and it's just all gamesmanship and it is due, I think, in part to with being, if I may make a generalization, a male-dominated profession.
No Disadvantages with Social Identity	Instructor expresses no issues with any social identities	This is the first time I taught in a decade and sure I got good teaching evaluations but that's just because yeah, I always do, because I'm a White male who's tall and no accent.

Observation Codes for ChE 101	**Definition**	**Example**
INSTRUCTOR		
Student-Centered Teaching	Instructor engaging in teaching methods (this can include zoom polls, pausing for questions, qualifying answers, connecting concepts to the real world, or other pedagogical practices)	The instructor started off by sharing his screen (the syllabus). He went onto canvas to walk students through different parts of the syllabus.
Cognitive Engagement	Working through problems with the students are clarifying concepts with students	At some points after he has explained some concepts, he does a couple problems with the class to show them how to answer the question.
Pedagogical Strategies	Using humor, call outs, tech to engage with students in class	He keeps a tone of humor throughout the class also apologizing when he has difficulty with his tech.

Instructor Inclusivity	Instructor making clear that he wants all students to feel included and also emphasizing accessibility	As he was going over the syllabus, he emphasized that he wanted students to have equal access to the material. He also discussed how the problems given will incorporate DE&I.
Instructor Response to Student Feedback	Instructor discusses in class with students about their evaluations or polls trying to determine how to incorporate student feedback	Listens to students' feedback in class and explains that he is going to scale the quizzes back
Personal Interaction	Personal interaction with student during class	There is a man of color who says "you may have already said this but…" A Black woman asks a question and says I may be confused… but the instructor says: "You are thinking exactly correctly."
Classroom Interaction	Interaction with instructor during class (asking or answering questions and the instructor's response). This includes unmuting and calling out answers or asking questions as well as using the chat function	He encourages questions throughout the classes and many times says, "that's a great question!"
Peer Interaction	Peer interaction in class either in breakout rooms or in the Chat	Students also interacted with each other in the chat answering each other's questions.
SOCIAL IDENTITY		
Gender	Women or men participate in class in certain ways that are distinct	There is a woman who asks a question but doubts herself (Am I just thinking incorrectly?). Another woman says, "I'm sorry if you already answered this."

ENGINEERING CULTURE		
Engineering Culture	Discussion of aspects of engineering culture whether positive or negative	One student (appears to be a woman of color) shares that she is happy that they are discussing this because they don't often get to do this as engineers.
Student Self-Doubt	Student appears to doubt their answers or questions	A few women when have asked questions say things like "Does that make sense? This may be dumb. I'm not sure if this makes sense" No man in the course has used any of these things.

Observation Codes for ChE 201	**Definition**	**Example**
INSTRUCTOR		
Student-Centered Teaching	Instructor engaging in teaching methods (this can include zoom polls, pausing for questions, qualifying answers, connecting concepts to the real world, or other pedagogical practices)	He writes, draws, uses arrows, definitions, equations as he goes through the material.
Cognitive Engagement	Working through problems with the students are clarifying concepts with students	He consistently works through problems in between the zoom polls. In once class he made connections to the world by giving examples of reactor designs.
Pedagogical Strategies	Using humor, call outs, tech to engage with students in class	When he emphasizes certain concepts, he will say "I know it's a tricky concept" or "this is a little tricky" He does 2-3 zoom poll problems in class and then works though each problem with the class showing them each step to solve.

Instructor Inclusivity	Instructor making clear that he wants all students to feel included and also emphasizing accessibility	Instructor at the beginning of class makes it clear that he wants everyone to feel included in the course and to let him know of any needs they have
Instructor Response to Student Feedback	Instructor discusses in class with students about their evaluations or polls trying to determine how to incorporate student feedback	Instructor does a poll when to have the exam to make sure that they are not overly stressed.
Personal Interaction	Personal interaction between student and instructor (office hours, before or after class, during break, or outside of class) This can also include emails or any virtual communication; can include communication with teaching team	At one point a woman unmutes and is apologetic when she asks a question. He apologizes for being confusing. He is often apologetic in class, apologizing to students for confusion.
Classroom Interaction	Interaction with instructor during class (asking or answering questions and the instructor's response). This includes unmuting and calling out answers or asking questions as well as using the chat function	He tells them not to be discouraged by the problems and to ask questions. He likes to us the word “tricky” by saying this is a tricky point, or this is a tricky problem.
Peer Interaction	Peer interaction in class either in breakout rooms or in the Chat	Students interacting through the chat
SOCIAL IDENTITY		
Gender	Women or men participate in class in certain ways that are distinct	In one class he asks them to recall: remember this from your previous courses-recall assumptions.
ENGINEERING CULTURE		

Engineering Culture	Discussion of aspects of engineering culture whether positive or negative	Instructor engages in behavior that is based on acting “neutral” or “merit-based”
Student Self-Doubt	Student appears to doubt their answers or questions	In one class, a woman had a question about homework but prefaced her question by saying “if I’m allowed to ask”.

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