A Cloak of Invisibility:

Women Engineers' Experience in Virtual Classes During COVID-19

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While women have made considerable strides in accessing engineering programs, their experiences inside of engineering classrooms remain for the most part "chilly" and unwelcoming. Until now, the work documenting women's experiences and the outcomes that result have been largely focused on traditional face-to-face instruction. The COVID-19 pandemic forced universities to pivot quickly to virtual instruction, and though the pandemic and its consequences are themselves tragic, this shift provided a sort of natural experiment to understand how women experience the remote classroom and if and how they describe those experiences as different from their previous experiences in the traditional classroom. Initial research on the impacts of COVID-19 and virtual learning in higher education have shown that students face new barriers for both entry and for continuing and completing their studies (Department of Education, 2021). Prior research has found mixed benefits of online education for women (Caspi et al., 2008), but has shown that in some virtual scenarios women participated more frequently than in face-to-face instruction (Anderson & Haddad, 2005), and when provided with anonymity, women contributed more assertive remarks during class (Bellman et al., 1993). But none of this work has been specific to undergraduate STEM or engineering courses.

The current study focused on three interviews with women engineering undergraduates during the pandemic that are part of a larger five-year effort to follow a cohort of engineering women from the first college year through graduation. Prior to the COVID-19 pandemic, during the women's first and second college years, the women revealed that their men peers often displayed arrogance that negatively impacted the way they experienced the classroom. For this study, we examined how virtual instruction during the COVID-19 pandemic provided opportunities and barriers for women engineers in their classroom experiences that may have differed from previous face-to-face instruction.

The following research questions were addressed:

RQ1: How do women in engineering experience the virtual classroom?

RQ2: What are the gendered opportunities and barriers women face in the virtual classroom?

Ultimately, we sought to understand how, if at all, the remote environment changed the learning climate in a way that impacted women, specifically. Findings indicate that the anonymity provided by online instruction decreased the performance anxiety that women in engineering often feel in traditional classrooms, and as a result, they engaged more in virtual learning environments. As engineering classroom spaces are often described as "chilly" for women, results from this study have the capacity to enhance climates for students who have not been traditionally represented in this discipline (Hall & Sandler, 1982/1984; Caspi et al., 2008). Identifying the specific ways that classroom cultural norms changed in virtual environments so that women were more comfortable participating can reveal new approaches to addressing climate issues. As the COVID-19 pandemic propelled many institutions and faculty to embrace new approaches to pedagogy, findings from this study can be applied to the variety of emerging learning contexts, enhancing climates for women engineering students across educational environments.

Impact of COVID-19 on Teaching and Learning

It is important to note that pivoting to online learning as a direct result of a global pandemic had differing effects on students and instructors than planned virtual education (Lassoued et al., 2020). Oliveira et al (2021) indicates that online learning should occur with intentional planning and design, which was not possible due to the emergency shift to online instruction as the world attempted to navigate the onset of the COVID-19 pandemic (Hodges et

al., 2020). Due to the immediate transition to remote instruction, some professors were ill-equipped to teach exclusively online (Adedoyin & Soykan, 2020; Rasheed et al., 2020). As colleges and universities were managing a wide variety of issues, many of which were unrelated to teaching, the ability to provide immediate and on-demand training for the use of educational technology was extremely limited, leaving professors to navigate the shift with limited support from institutions (Lassoued et al., 2020; Oliveira et al., 2021). This lack of support and training significantly impacted both the experience of students, as well as instructor confidence and morale (Oliveira et al., 2021; Watermeyer et al., 2021). In addition to updating their delivery method quickly, instructors may have also needed to adjust the content of their courses to better align with online learning (for example, altering slides to reduce text for the purposes of engagement or incorporating group work to allow for more interaction). Students indicated that they were negatively impacted by the impersonal nature of remote instruction, which they described as lacking opportunities for interaction and contact, yet most students had their cameras off during remote instruction, which may have impacted their ability to connect in a meaningful way with instructors (Oliveira et al., 2021).

Beyond the pedagogical implications of the shift to remote learning, students' ability to learn were also impacted by logistical changes in their environments (Oliveira et al., 2021). For example, as students may have returned to permanent residences, they may not have had physical spaces where they could focus solely on their academic work (Gillis & Krull, 2020), and the presence of family members may have distracted them from adequately engaging in online courses (Adedoyin & Soykan, 2020). The shift to remote instruction due to COVID-19 not only impacted student satisfaction with educational experiences, but there were also negative psychological effects on students' learning (Gillis & Krull, 2020; Godoy et al., 2021). Dhawan

(2020) indicates that the immediate and "radical transformation" (p. 14) of learning environments necessitated by COVID-19 generated substantial stress on students and instructors, creating less than ideal circumstances. In fact, Godoy et al., (2021) found that nearly half of the students in their study on the psychological impact of the pandemic in remote learning environments indicated that students suffered from increased anxiety which impaired their ability to be successful in coursework. Understanding exactly how learning environments shifted as a result of the COVID-19 pandemic and the implications of the transition is an important context for examining the ways in which virtual education affected the climate, particularly for women, in engineering spaces.

Literature Review

While previous scholarship has demonstrated that there is a range of experiences in online learning environments for students, there is a limited body of literature which delineates differences by particular disciplines and gender (for exceptions, see Anderson & Haddad, 2005; Caspi et al., 2008; McKnight-Tutein & Thackaberry, 2011; McSporran & Young, 2001; Morante et al., 2017; Price, 2006). This review focuses on the pervasive stereotyping that women endure in engineering classrooms, as well as the differences in the climates of traditional learning environments and virtual education spaces. Prior scholarship on gender stereotyping in engineering and women's experiences in virtual education provided a framework for interpreting our participants' lived experiences. Further, this literature provides a frame of reference for understanding our findings in relation to what has been previously documented about women's gendered experiences in engineering.

Gender Stereotyping in the Classroom

Women's decreased participation in the classroom has been attributed to a "chilly" climate, as it relates to the systematic discrimination that disadvantages women in academic settings (Hall & Sandler, 1982/1984; Caspi et al., 2008). Prior research related to gender differences in face-to-face classroom behavior found that women tend to speak less frequently and confidently than their men peers (Caspi et al., 2008). In addition, instructors interact with men more readily in classroom environments and provide them with more feedback (Sadker & Sadker, 1994). In engineering programs specifically, disciplinary culture is defined by traits most often associated with masculinity (Parson & Ozaki, 2018; Rhoton, 2009) and thus, classroom interactions can often take on patriarchal models where women are dismissed from being knowledge holders (Seron et al., 2016). "Dude culture," the centering of hypermasculine ideals and behaviors (Miller, et al., 2020), often overtakes the engineering classroom, and forces women to take a backseat, resulting in less participation, lack of relationship building with faculty, and being forced into stereotypical feminine roles in group work (e.g. group secretary) (Miller, et al., 2020; Seron et al, 2016). As women are forced to navigate environments hallmarked by hegemonic masculinity, this can diminish women's ability to feel accepted (Cheryan et al., 2017; Seron et al., 2016), and negatively impact their sense of belonging and role confidence (Cech et al., 2011; Chemers et al., 2011; Jordan, 2014; McGee & Martin, 2011).

Gendered Participation in Virtual Education

Research on the benefits of virtual education on participation are mixed, and the work is not specific to STEM or to engineering. Some studies have found equal participation, while others show differences by gender (Cai et al., 2017; Nistor, 2013; Tang et al., 2021; Yu, 2021). Most studies highlight that number of participants, type of participation, and dynamics of engagement are fundamental when considering differing contexts and their impact on gendered

participation (Caspi et al., 2008). Regardless of the level and differences in engagement by gender in remote learning contexts, it would be capricious to disregard the idea of the body in virtual spaces. While those participating in online education may not be physically present in the same spaces, individuals' do not take on gender-neutrality in these contexts. Yoon (2021) notes that "the pedagogical spatiality of a virtual space is entirely dependent on every performative action of its participants" (p. 582). In other words, learners use their bodies to employ common classroom-based actions, many of which are gendered and influenced by who holds power (Brickell, 2005). As a result, individuals' consistent engagement in and the pervasiveness of gender performativity erases the possibility of a gender-neutral body in virtual learning environments. In considering how technological spaces affect individuals' perceptions of gender, one must recognize that masculinity and technology work together to replicate and reify hegemonic, sexist communications and interactions (Faulkner, 2001; Yoon, 2021). This is an important point to consider as we examine the effects of remote education on women's perceptions of anonymity and the implications of the idea of digital bodies on their experiences in online classrooms.

Even considering the notion of the gendered body in online spaces, remote learning contexts may still provide a cloak of invisibility that some women appreciate. Men's participation in online educational communications often utilizes language that mirrors the current gendered patterns that occur during in-person interactions, with men employing domineering attitudes and assertive self-confidence (Herring, 1993). In fact, Yoon (2021) argued that online classroom environments may produce "more frequent 'aggressive and offensive' (Yates 2001, 22) social interactions, engendered by an attitude that is 'less civil and less tolerant of others' (Johnson-Bailey 2016, 51)" (p. 579). At the same time, women's contributions to

online class discussions are described as ambiguous, doubtful of themselves and hallmarked by frequent apologizing. However, more recent research demonstrates that it is possible that the chilly climate that women experience in face-to-face instruction does not translate in the same ways to the virtual environment. Women log in, post, and read more messages in online formats than their men peers (Caspi et al., 2008; Gunn, et. al., 2003), achieve parity in participation in online mixed gender discussion groups (Wolfe, 2000), and are more likely to participate in class as their degree of anonymity increases (Freeman et al., 2006). These high rates of engagement translate into increases in academic achievement, with a number of studies demonstrating that the students who participate in online learning environments the most, perform better than classmates who engage at lower levels (Morante et al., 2017; Price, 2006). Given that the work of a number of scholars suggests that online learning environments may contribute to higher levels of success for women than in-person classroom contexts, the implications of this study will be a worthwhile contribution (Anderson & Haddad, 2005; McKnight-Tutein & Thackaberry, 2011).

Theoretical Framework

Using a gender lens to analyze the culture of engineering classrooms is essential in our understanding of how genderism operates as a catalyst for how women participate in both face-to-face and virtual interactions. Butler (1997/2013) explains that gender identity is created by the repetition of performative acts that help to create a reality that upholds cultural understandings of what it means to be a woman. To Butler, actions do not simply create gendered roles or stereotypes, but actions, in and of themselves, set into motion a series of related gendered realities, norms, and systems. This understanding helps us to approach the work with the ability to center women's narratives in how they "do" gender in engineering, but also their observations

and perceptions about what it means to perform as a woman in both face-to-face and virtual classroom settings.

We also consider feminist intersectionality as an analytical lens in order to examine the nuanced experiences of how gender and race interact simultaneously in the classroom. Intersectionality theory allows for the understanding of multiple dimensions of identity (McCall, 2005), and how these dimensions may occur simultaneously, which might include gender, race, ethnicity, ability, sexual orientation, and socioeconomic status, among others (Ro & Loya, 2015). These dimensions help to shape an individual's experiences, perceptions, and beliefs (Crenshaw, 1991), and produce a more nuanced understanding of their reality (Cole, 2009). This understanding foregrounds how we consider our participants' experiences in the engineering space both in person and virtually.

In addition, the concept of anonymity is considered as it may reduce the restraint that women in engineering feel that their men peers or professors impose upon them when they are in more visible face-to-face classroom settings. These social restraints may be a result of traditional stereotypes, but may also be self-imposed to a certain extent (i.e. performativity) (Butler, 1997, Butler & Athanasiou, 2013; Eagly, 1987; Geis, 1993). The salience of social identity is not dependent on group members alone, therefore anonymity in the virtual classroom may not provide women engineers with group membership (i.e. being a man in engineering) and may still exert considerable influence on the women's experience (Turner, 1991).

Methods and Data Sources

This study took place at a research institution in the Mid-Atlantic region of the United States, and was part of a larger, longitudinal study that sought to understand issues of self-efficacy, sense of belonging and gendered classroom behavior and experiences for women in

engineering beginning in the first college year and continuing through graduation. This study utilized data from three interviews conducted during the COVID-19 pandemic, including: one month after the change to virtual education (April 2020) during the third college year, and mid fall (October 2020) and late spring (April 2021) during the fourth college year. 17 women participated in all three interviews. Due to the pandemic questions were added to these protocols related to experiences and perceptions of online classes, comparisons to face-to-face instruction, and gendered understandings of the virtual environment. The sample represented multiple engineering majors, and race/ethnicities, including: 10 White, 1 Latinx, 3 Black, 2 Biracial, and 1 Asian women (see Table 1). At this institution, face-to-face instruction was halted in early March 2020 due to the COVID-19 pandemic and remained largely virtual for the subsequent 2020-2021 academic year.

Table 1

Participant Profiles

Pseudonym	Ethnicity	Major
Angela	White	Bioengineering
Anna	Asian	Mechanical
Brianna	Latinx	Bioengineering
Britney	White	Mechanical
Chloe	White	Civil
Hannah	Biracial	Industrial
Jordan	White	Environmental
Katherine	White	Chemical
Lucy	Biracial	Chemical
Mia	White	Chemical
Monica	Black	Mechanical
Nasha	Black	Computer
Nicole	Black	Mechanical
Paige	White	Industrial
Samantha	White	Mechanical
Sophia	White	Industrial
Taylor	White	Industrial

We utilized interpretative phenomenological analysis (IPA) (Smith et al.,2009) in our data analysis process. IPA focuses on understanding "lived experience" from the perspective of the "experiencing person" (Bazeley, 2013; Smith et al., 2009) and was used to examine and identify the key experiences or emergent key themes for the experiencing group (Smith et al., 2009). IPA allowed us to emphasize the role of individual women as intertwined within wider systems, specifically in this study, the engineering environment.

Findings

In examining the outcomes of a shift to virtual learning, it is important to consider how exactly the classroom environment changed for students. Literature on women's experiences in traditional engineering classrooms clearly articulates that they are often excluded (Miller et al., 2020; Murray et al., 1999; Tate & Linn, 2005), yet our findings indicate that because their gender was not always visible or obvious, women felt more comfortable participating in online contexts.

Virtual Anonymity Decreases Anxieties Women Feel in Classroom Environment

Women in engineering spoke specifically about how the online environment provided them opportunities to feel present and engaged in class without the concern of judgment from others. Being able to ask questions in the chat function, or speak up without having to be seen (i.e.cameras off and using only audio), gave them a level of protection from both their peers and professors. This allowed the women to feel less pressure and become more engaged in classroom activity. Brianna, explained that the inability to see peers in remote classes lessened feelings of peer pressure. She stated, "You really can't tell their body like expressions and the face, or also like the way they say things, so it's a little hard to feel how they're interacting." Nicole shared similar sentiments stating:

> I think it [remote instruction] does alleviate some of the pressure. I never talk during [in-person] class, ever, raising my hand or anything. But I have asked some questions in the chat a couple times. I feel like that has shifted 'cause you're kind of like a faceless, voiceless name. You're just words. So, no one knows you. Even if I met these people in person, I don't think they'd know who I was based on my questions asked during class. That's different.

Some participants discussed that they were more comfortable engaging in remote classes than traditional in-person courses due to explicit changes in behavior of their men peers. For example, Chloe shared that shortly after the onset of COVID-19 and the shift to online learning, many of her men peers simply stopped coming to certain classes, and a subsequent result of this was that women were able to converse with the professor comfortably and without the pressure of those who traditionally dominate conversation present. In contrasting this experience with that of her pre-COVID coursework, Chloe described how when men would "talk in class, even if they ask absolutely stupid questions, it comes off as a joke rather than them being stupid" whereas she felt like "when I ask a question, it feels like people are like, we already know what this is, can we please move on, and I'm like, sorry, I didn't phrase it as a joke, I just don't know." The change in men's attendance in some courses thus created an environment where women didn't feel pressure to fulfill any particular expectations others had of them or to compare themselves to their men peers.

Women of Color also spoke about the benefits of online learning, anonymity provided them an opportunity to participate without being judged by their race/ethnicity. Brianna explained how participating virtually without using her video camera removed her fear of the

professor's potential racial bias and provided her the chance to engage in ways she might not have before, she said:

> [The professor] can be racially biased or… be more biased towards men or towards women or just like the [facial] expression you put in class can also make a big difference between the professor takes your answer or not, or your question. Like if someone looks extremely confused, the professor might not ask them for participation or stuff like that. It's just facial expression sometimes can like, can change the perspective of the professor when the professor is teaching you.

Not only did remote instruction aid in removing or lessening Brianna's fears of racial bias, the ability to turn off her camera and simply speak to the instructor without any concern of how her expression might be interpreted enabled her to participate in class discussion more. Monica elaborated on Brianna's sentiments, stating:

> But with remote classes, I'm never thinking about that at all because I could just turn off my camera. And so I feel like I'm learning in the most comfortable setting, I would say, like I'm not worried about other people. Also, in voicing my opinion in the class, I spoke in a lecture. It wasn't about the lecture in general. It was about a question that he was having, and I literally just – I went and turned on my mic, and you know, voiced my opinion about how we should do the exam, because I wasn't really worried about anybody knowing that it was me.

Monica also explained how her feeling of anonymity in the virtual environment provided her more comfort in her learning and eased the anxiety she felt in the face-to-face classroom setting:

> Because [class is] remote, it takes away a lot of things that I stress about when I'm in class. It helps to reduce anxiety when I'm in the classroom setting, and then also I feel

less anxiety about people looking at me… I guess I feel more invisible… but I feel like I can be comfortable that way.

Paige explained how engaging in remote contexts decreased her anxieties about comparing herself to men classmates, sharing that because she no longer encounters men peers outside of class, she simply does not think about how her work ethic compares to theirs. She shared, "You kind of gauge someone's work ethic based on like what you see them doing, whether or not like me turn assignments in on time, or whether or not you see them at the library, or things like that… And I think because you're online, you don't get to see that."

For these women the shift to remote instruction eased the pressures they experienced and, in some cases, feelings of competition they felt with their peers. This occurred as they realized that online classes could afford a sense of anonymity or invisibility that was not possible for them in the traditional classroom space.

Virtual Learning Provides Opportunities for Increased Engagement

The virtual environment also provided these women with new ways to engage in class that weren't available to them than their previous face-to-face classroom experiences. The women noted that the logistical changes resulting from online instruction benefitted their learning significantly, with Brianna indicating "… I definitely like it [remote instruction] better just because I'm able to stop the video and take notes on my own pace…" Brianna continued, sharing "I feel like for some classes, I enjoy it more offline just because I'm able to get it done so much faster than when I was actually in class…" Paige echoed Brianna's sentiments, stating:

Other students are in different time zones, so they [professors] record all the lectures. So half the time, I'll just go back and re-watch a lecture at like two times the speed, and get the same content but within a shorter period of time. So, I mean, I like the flexibility that remote has.

It's nice to not have to wake up before 8:00 a.m. I wake up, go over to my laptop and log in, and like that's that.

Monica shared how virtual environments were less exhausting and allowed her to demonstrate her knowledge and skills in new ways. She shared

> So, I feel like I'm less exhausted [with virtual instruction], and then – so whenever I have to learn, I'm ready to learn. And then also another thing, I have a lot of take-home exams that are open note, open book, and I feel like because of that, I'm learning better. Again, this has to do with my personality type. I'm not cramming for the exam. I'm saying like, these are the concepts I know. I've written out a study sheet, and I can refer to it, and I'm learning from it that way.

Instead of feeling like their voices were stifled by their men peers, the women were able to interact with their professors much more easily. For example, Nicole shared:

> I feel like when you're in a normal classroom setting there are gonna be the people that do a lot better and some that do a lot worse, and there will be the people that are up high that don't want to help anybody else 'cause they want to keep their high end of the curve or whatever. But I feel like when we went online, I feel like even those people were willing to help people out in remote learning just because they realize this whole thing is unprecedented and there are a lot of people I think that have engineering majors.

However, this was not necessarily the case for women in heavily men dominated majors, especially if the virtual space created by the professor was more hands off or if the class was run asynchronously. In these environments the women felt that they were left to work solely with their men peers. Chloe explained:

I just think honestly that [women are] more willing to ask questions to our professors… but I feel like there's a difference between asking a teacher for help and asking your peers for help… to ask the guys in the group chat, why waste your time asking them if you don't feel like they're gonna help you out if you need it?

Overall, virtual environment provided the women in this study with the ability to slow down or pause the delivery of course content, listen to a recorded lecture multiple times, if needed, or pose questions to instructors more than they had previously done in face-to-face courses, all of which facilitated high levels of participation in their courses. Even when women encountered challenges during the aftermath of the shift to online instruction during COVID-19, our analysis suggests that their increased comfort and engagement in class enabled them to participate and collaborate with their peers in new ways.

Discussion

This study utilized interview data from 17 women to understand the role of genderism within the context of the virtual classroom—specifically, how women experience the virtual classroom, including the gendered opportunities and barriers women face. We found that virtual anonymity decreased women's anxieties in the classroom environment and that with this invisibility they participated more than they had in the traditional classroom. This was especially the case if these virtual environments were supportive, and the professors were engaged with their students. These findings support previous research on women's engagement in remote learning contexts, in which scholars found that women's level of engagement in online classes increase as does their degree of anonymity (Caspi et al., 2008; Freeman et al., 2006; Gunn, et. al., 2003, Wolfe, 2000). Overall, our study suggests that the anonymity provided in remote learning environment changed the way women experienced the climate in their classrooms, the

virtual environment seemed less "chilly." This virtual anonymity in turn appeared to help women feel more comfortable participating in the classroom. While these findings were within the context of virtual classrooms during the COVID-19 pandemic, we hope that key insights from these virtual classrooms can be learned from and adapted to face-to-face instruction as the pandemic continues to ease in severity (Hodges et al., 2020; Oliveria et al., 2021).

These data contribute theoretically to the literature by suggesting that a virtual mode of instruction may have diminished the emphasis of gender performance in these classrooms which potentially contributed to a reduction in gender stereotyping. As a result, it is possible that women felt more comfortable engaging in the learning environment as an emphasis on hypermasculine ideals and behaviors "took a backseat." Through this increased comfortability within the classroom, women appeared to engage with the course more. Taken together, this suggests that the change from in-person to virtual instruction necessitated changes to the ways in which women and men felt inclined to uphold gendered norms within the context of the classroom. In other words, it is possible that performative acts, which upheld the gendered realities and norms of the classroom, were interrupted--contributing to a context which made "performing" gender less salient and subsequently promoted group membership in the engineering environment. By taking out the role of gender in the learning context, it helped women to become more engaged and, overall, perform better through fostering an environment that felt more inclusive and welcoming for women, potentially contributing to a higher sense of belonging.

While this work suggests that a "cloak of invisibility" was helpful for women, it also begs the question—how can we foster environments that de-center the role of gender in the classroom context while also minimizing the onus on women to perform (or not perform) in ways that

interrupt the reinforcement gendered realities, norms, and broader systems of the engineering context (Yoon, 2021)? COVID-19 created a natural experiment in which the role of gender was interrupted through the sudden use of virtual instruction. However, moving forward, it is also important to use these insights and adapt them to face-to-face instruction contexts as women have returned to in-person classrooms following COVID-19 lockdowns. Perhaps then, future research should explore further the specific factors that promote these more inclusive, and anonymous, environments for women, which can then inform tangible actions for implementation to improve these engineering contexts for women.

Implications for Research

The virtual classroom seemed to be helpful in providing anonymity to women in engineering, suggesting that to some extent the stereotypes of being a woman in the classroom were diminished and impacted classroom norms less. However, our findings are mainly within the context of gender as binary. Given that gender is better represented as a continuum rather than as a binary, understanding the experiences of trans women and non-binary students in the context of the engineering classroom is important to ensure that the engineering environment can be modified in a way that helps students of all genders to succeed, especially in these learning contexts which overvalue and reinforce masculinity. Additional research should make a concerted effort to understand the experiences of not just women, but also people who identify along different dimensions of gender identity and expression. Qualitative research especially can be helpful in understanding these experiences. Given the need for large sample sizes in quantitative research, additional qualitative research can help us understand the experiences of students who fall outside the gender binary without concern about low power to detect statistical differences across students. Further understanding the experiences of students who fall outside

the gender binary can also further inform feminist theory and feminist intersectionality when coupled with additional identities, such as racial identity, ability, socioeconomic status, and others.

Additional research should explore the boundary conditions of anonymity for women in the engineering classroom. While our research suggests that anonymity was a positive force for women, it is also important to understand the limits it may pose which may turn the tide back to one that is less inclusive in these contexts. Can there be too much anonymity to the point where women proceed to disengage with the course content? And can too much anonymity promote a culture of individualism which diminishes the existence of supportive communities within the engineering classroom context? Understanding the amount of anonymity that is helpful for women can go a long way in ensuring that it is still a useful tool for women, rather than one that becomes negative over time. Finally, what might be tangible ways to de-center hegemonic masculinity in the face-to-face classroom without placing the onus on women? There may be something important about the anonymity that was created by moving to the virtual classroom that benefited women by not making them put in effort to create the anonymity they experienced and benefited from to begin with. Thus, it is possible that they enjoyed the benefits of anonymity, at least partially because the context facilitated this, and it did not need to be created by women in the first place. Further, understanding the key ingredients to promoting anonymity can be important for future translation to the in-person classroom context, especially if these key ingredients are subject to reproduction of each other through classroom norms. Further research should thus explore ways to promote a culture where the psychological benefits of anonymity are proffered in in-person contexts when total anonymity may not be logistically possible.

Implications for Practice

Implementation of findings from this study can further change and improve learning contexts in constructive ways and contribute back to the theoretical frameworks through which we understand and conduct research in this area. As the world emerges from a post COVID-19, implementing the elements that appeared to be useful for women when classes were virtual to classes with face-to-face instruction is imperative. Further, we recommend further fostering these environments to make them more welcoming for women, non-binary and transgender students—as well as students of color to de-center hegemonic masculinity and white supremacy.

We emphasize the importance of adapting these insights to in-person classrooms, as classrooms return fully to in-person learning. Perhaps a de-emphasis on what it means to be a woman in engineering classroom contexts can be a helpful tool to help women thrive. Ideally, this is something that can be initiated by the instructor of the classroom to deconstruct the myths and stereotypes surrounding women in engineering, as well as de-center hegemonic masculinity in the classroom. Students might then engage with this thesis and have a structured discussion on the drawbacks of hegemonic masculinity for all students, not just women, in an effort to weaken the salience of genderism in that classroom environment. This might not just help women, but also help students who identify as non-binary and transgender, to feel as though they can actively participate in the classroom without feeling the climate is chilly for them. Overall, these key insights can be used to improve classroom climates in traditional learning spaces for all students of minoritized backgrounds, not just women.

Conclusion

Overall, this study suggests that the remote learning environment during the COVID-19 pandemic changed the way women often experience the climate in their classrooms to one that is less “chilly.” This helped women feel more comfortable participating in the classroom. Although

women's gendered experiences are well documented in prior literature, this study and its preliminary findings provide a new opportunity to understand how the concept of anonymity impacts women's experiences in virtual engineering classrooms. This study also provides context to emerging literature on the impact of COVID-19 on higher education, and how virtual learning impacted our women participants in unique ways. Women engineers' experiences of the virtual classroom may be a factor for consideration as we seek to create more equitable learning environments for a post-COVID-19 world. We believe this work to be valuable in providing key insights that can be adapted to classrooms with face-to-face instruction as the pandemic continues to ease in severity.

References

Anderson, D.M., & Haddad, C.J. 2005, Gender, voice, and learning in online course environments, Journal of Asynchronous Learning Networks, 9(1). Available online at http://www.sloan-c.org/publications/jaln/v9n1/v9n1_anderson.asp#anderson7.

Bazeley, P. (2013). *Qualitative data analysis: Practical strategies*. Sage.

Bellman, B., Tindimubona, A., & Arias, A. Jr., (1993). Technology transfer in global networking: Capacity building in Africa and Latin American. In L. Harasim (Ed.), Global networks: Computers and international communication (pp. 237–254). Massachusetts: MIT Press

Brickell, C. (2005). Masculinities, performativity, and subversion: A sociological reappraisal. *Men and masculinities*, *8*(1), 24-43.

Butler, J. (1997). Response to Lynne Layton's:"The Doer behind the Deed Tensions and Intersections between Butler's Vision of Performativity and R. *Gender and Psychoanalysis*, *2*(4), 515-520.

Butler, J., & Athanasiou, A. (2013). *Dispossession: The performative in the political*. John Wiley & Sons.

Caspi, A., Chajut, E., & Saporta, K. (2008). Participation in class and in online discussions: Gender differences. *Computers & Education*, *50*(3), 718-724.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011). Professional role confidence and gendered persistence in engineering. American Sociological Review, 76(5), 641-666. https://doi.org/10.1177/0003122411420815

Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. Journal of Social Issues, 67(3), 469-491. https://doi.org/10.1111/j.1540-4560.2011.01710.x

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others?. *Psychological Bulletin*, *143*(1), 1.

Department of Education (2021). Education in a Pandemic: The Disparate Impacts of COVID-19 on America's Students. Retrieved from: https://www2.ed.gov/about/offices/list/ocr/docs/20210608-impacts-of-covid19.pdf

Eagly, A. H. (1987). Reporting sex differences. *American Psychologist, 42*(7), 756–757.

Freeman, M., Blayney, P., & Ginns, P. (2006). Anonymity and in class learning: The case for electronic response systems. *Australasian Journal of Educational Technology*, *22*(4).

Geis, F. L. (1993). Self-fulfilling prophecies: A social psychological view of gender.

Gunn, C., McSporran, M., Macleod, H., & French, S. (2003). Dominant or different? Gender issues in computer supported learning. *Journal of Asynchronous Learning Networks, 7(1),* 14–30.

Hall, R. M., & Sandler, B. R. (1982). The classroom climate: a chilly one for women. Washington, DC: Project on the Status and Education of Women, Association of American Colleges.

Hall, R. M., & Sandler, B. R. (1984). Out of the classroom: a chilly campus climate for women? Washington, DC: Project on the Status and Education of Women, Association of American Colleges.

Hodges, C. B., & Fowler, D. J. (2020). The COVID-19 Crisis and Faculty Members in Higher Education: From Emergency Remote Teaching to Better Teaching through Reflection. *International Journal of Multidisciplinary Perspectives in Higher Education*, *5*(1), 118-122

Jordan, K. L. (2014). Intervention to improve engineering self-efficacy and sense of belonging of first-year engineering students (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3673228).

McGee, E. O., & Martin, D. B. (2011). "You would not believe what I have to go through to prove my intellectual value!" Stereotype management among academically successful Black mathematics and engineering students. *American Educational Research Journal*, *48*(6), 1347-1389.

Miller, R. A., Vaccaro, A., Kimball, E. W., & Forester, R. (2020). "It's dude culture": Students with minoritized identities of sexuality and/or gender navigating STEM majors. *Journal of Diversity in Higher Education*.

Murray, S. L., Meinholdt, C., & Bergmann, L. S. (1999). Addressing Gender Issues in the Engineering Classroom. *Feminist Teacher*, *12*(3), 169–183. http://www.jstor.org/stable/40545825

Oliveira, G., Grenha Teixeira, J., Torres, A., & Morais, C. (2021). An exploratory study on the emergency remote education experience of higher education students and teachers during the COVID-19 pandemic. *British journal of educational technology : journal of the Council for Educational Technology*, 10.1111/bjet.13112. Advance online publication. https://doi.org/10.1111/bjet.13112

Ro, H. K., & Loya, K. I. (2015). The effect of gender and race intersectionality on student learning outcomes in engineering. *The Review of Higher Education*, *38*(3), 359-396.

Sadker, M. P., & Sadker, D. M. (1994). Failing at fairness: how America's schools cheat girls. New York: Scribners Sons

Seron, C., Silbey, S. S., Cech, E., & Rubineau, B. (2016). Persistence is cultural: Professional socialization and the reproduction of sex segregation. *Work and Occupations*, *43*(2), 178-214.

Smith, J. A., Flowers, P., & Larkin, M. (2009). Interpretative Phenomenological Analysis: Theory, Method and Research. In *Interpretative Phenomenological Analysis: Theory, Method and Research* SAGE Publications.

Tate, E. & Linn, M. (2005). How does identity shape the experiences of women of color engineering students? *Journal of Science Education and Technology, 14*(5-6), 483-493.

Turner, J. C. (1991). *Social influence*. Thomson Brooks/Cole Publishing Co.

Watermeyer, R., Crick, T., Knight, C. & Goodall, J. (2021). COVID-19 and digital disruption in UK universities: afflictions and affordances of emergency online migration. *Higher Education* 81, 623–641. https://doi.org/10.1007/s10734-020-00561-y

Wolfe, J. (2000). Gender, ethnicity, and classroom discourse. Written Communication, 17(4), 491–519.

Yoon, H. (2021) Digital flesh: a feminist approach to the body in cyberspace, Gender and Education, 33:5, 578-593, DOI: 10.1080/09540253.2020.1802408