



Belonging Interrupted: Toward an Understanding of How Virtual Learning Impedes Women Students' Belonging in Engineering

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Abstract

Although the effects of COVID-19 were felt by all students, the pandemic exacerbated the barriers to belonging for women in engineering. Little work to date has investigated women's experiences during the pandemic in disciplines that are hallmarked by masculinity. What scholarship has been completed on pandemic-necessitated virtual instruction has not examined how women's experiences and sense of belonging differed by the college year in which this disruption in their learning environment occurred. Utilizing data from seven focus groups conducted in March 2022 with 22 students, this study investigates how pandemic-induced virtual instruction is related to sense of belonging for women within their engineering majors. We found not only that the disruption caused by the pandemic had differential outcomes for students, but that these differences were mainly related to the year in which pandemic-induced virtual instruction occurred. This study highlights the importance of focusing on belonging and related issues as women transition into their major. We offer implications and recommendations for practice and research based on the differential outcomes found.

Keywords Sense of Belonging · COVID-19 · Gender · Engineering · Online Instruction

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Introduction

While great progress has been made in increasing the participation of women in science, technology, engineering, and math (STEM), engineering remains heavily dominated by men, with women accounting for only 24% of engineering bachelor's awarded across the U.S. (National Center for Science and Engineering Statistics, 2023). The barriers that women in engineering experience, including social exclusion, often result in unwelcome and “chilly” climates and directly influence likelihood of persistence to graduation (Caspi et al., 2008; Hall & Sandler, 1982; Walton et al., 2015; Wilson et al., 2015). The masculine culture that is a hallmark of engineering can discourage women and harm their sense of belonging, negatively impacting their academic pursuits (Cheryan et al., 2017). Within the context of socialization, sense of belonging, or an individual's feeling that they are accepted within a group, has long been documented as integral to women's success in STEM spaces (D. Wilson & VanAntwerp, 2021). Until recently, the work documenting women's experiences within these contexts and the outcomes that result have been largely focused on traditional face-to-face instruction. However, the onset of COVID-19 and subsequent immediate shift to remote instruction significantly influenced women engineering students' ability to build relationships with peers and develop their identity as engineers (Dhawan, 2020; Gillis & Krull, 2020; Godoy et al., 2021).

This study focuses on undergraduate women engineering students in the transition to their engineering specific majors, which at many institutions and at the one where this study is located occurs in the second college year. Currently, 60% of ABET-accredited engineering programs place students in common engineering curriculum during their first year of college and prior to entry into courses within a specific engineering major (Chen et al., 2013). Due to COVID-19, this transition into and then through the major occurred virtually for our participants, thus we addressed the salience of virtual college within what our participants shared. Our goal was to understand how remote learning shaped the overall experience of and sense of belonging of women engineering students, and in what ways this differed based on the point at which virtual learning was introduced into the college experience. Specifically, the research question we addressed was: How was women's sense of belonging within their majors and in engineering related to the virtual college experiences they shared?

Review of Literature

Sense of belonging is often used as a framework to understand an individual's feelings of connectedness in relation to their position within a group in particular contexts (Rosenberg & McCullough, 1981; Strayhorn, 2018). Belonging, an individual's feeling of being accepted and included by others, is a basic human necessity, and as a result, one's sense of belonging can predict a variety of psychological, social, and behavioral outcomes (Lewis et al., 2017). Scholarship demonstrates the importance of belonging for all students, but in particular for students who may be underrepresented in specific spaces, such as women in engineering (Allen et al., 2021; Walton & Cohen, 2007). Despite the wealth of research on belonging for women

within in-person contexts, more studies are needed. Specifically, there is a gap in the literature that explores the impact of the pandemic on women's sense of belonging in engineering (for exceptions, see Bordel Sánchez et al., 2021; Means & Neisler, 2020). To frame this study, we review the literature on the criticality of sense of belonging on students' experiences, performance, and retention; how belonging activities shape particular class years and throughout the college experience; and the impact of COVID-19 on belonging for women engineering undergraduates. The continued prevalence of virtual learning (Prasetyanto et al., 2022) necessitates the need for this study which highlights the ways in which remote instruction impacts women engineering students' sense of belonging as they enter and pursue a degree in this discipline.

Sense of Belonging

Belonging is a critical component of students' collegiate experiences (National Academies of Sciences, Engineering, and Medicine, 2017; Strayhorn, 2018; Walton & Cohen, 2011). Sense of belonging affects individuals' perceptions, affect, and behaviors (Hurtado & Carter, 1997) and the consequences of a positive or negative sense of this psychological state can influence students' retention, persistence, academic adjustment, and academic achievement (Hausmann et al., 2007; Hurtado et al., 2012; Rodriguez & Blaney, 2021; Sax et al., 2018; Strayhorn, 2018), making it especially critical to address for underrepresented populations (e.g., women in STEM). When members of a marginalized group experience difficulty making social connections in particular contexts based on their salient social identities, belonging uncertainty can ensue (Walton & Cohen, 2007). The anxiety or stigmatization and subsequent negative social interactions that can result from being a member of an underrepresented group then perpetuate experiences of stereotype threat, further impeding marginalized students' sense of belonging (Binning et al., 2020).

Within academic environments in which one is underrepresented, as is the case with women in engineering, substantial threats to sense of belonging are experienced that are not experienced by those in the majority population (Allen et al., 2021; Walton & Cohen, 2007). Therefore, addressing underrepresented students' sense of belonging is critical for increasing retention and enhancing the potential for academic success.

Belonging throughout the College Experience

While some scholars have called for more personalized imaginings of how belonging needs can manifest for individuals (Ajjawi et al., 2023), there is literature that demonstrates common challenges that occur based on class year. In short, belonging challenges can vary at different points in time throughout students' undergraduate careers, regardless of major choice. For example, for those in their first year of college, transitioning into the larger campus community within one's institution and identifying peers with whom relationships can be built are known to be critical for this class year (Hausmann et al., 2007; Hurtado & Carter, 1997). Although significant attention and resources are directed at first-year student persistence and success,

recent research demonstrates that sophomores are highly dissatisfied (Boivin et al., 2000), experience a number of academic issues (Perez, 2020), and have high attrition rates, second to only first-year students (Schaller, 2009). Scholars have noted that the intensive resources and engagement directed at first-year students do not carry over into the sophomore year to address second year challenges, despite institutions' assumptions that this is the case (Gardner et al., 2009; Perez, 2020). The compounding of second year-specific challenges that students commonly experience is known as the "sophomore slump" (Freedman, 1956; Kennedy & Upcraft, 2010). Many of these struggles relate to major selection and transition and the consequences of challenges experienced through the major selection and transition process on academic self-efficacy (Schaller, 2009). While these academic-related challenges can and do negatively impact the persistence of second-year students, Perez (2020) found that some of the primary causes of sophomore's attrition are "poor or inadequate friendships or relationships, and a lack of belonging or sense of community" (p. 8). These findings reinforce the importance of strong social membership and acceptance within the major and institution. Given institutions' emergent shift to virtual instruction, students whose second year was impacted by COVID-19 likely experienced notable impacts on social belonging. This may especially be the case in engineering given that students are entering their major for the first time in their sophomore year, unlike most other majors on campus.

Students in the third year commonly experience academic challenges related to demanding disciplinary coursework, which for students in engineering majors often leads to attrition out of the discipline, and securing career preparation like internships (Correll et al., 1997; Rayman, 1993). In contrast, fourth year students are often focused on graduate school applications or job searching (Gardner & Van der Veer, 1998). The challenges associated with both the third and fourth years may be mitigated by relying on strong peer relationships and high sense of belonging within the major (Allen et al., 2008; Hurtado & Carter, 1997). Regardless of students' class year and the belonging activities associated with each, research demonstrates that when transition issues remain unaddressed, it can negatively impact the academic performance, persistence, and retention of undergraduates (Hurtado & Carter, 1997; Perez, 2020). Given institutions' emergent transition to online learning due to the COVID-19 pandemic, many college students' belonging activities, transitions into their majors, and sense of belonging largely went unaddressed (Peacock et al., 2020).

COVID-19 and Sense of Belonging

Emerging research has documented the specific ways that transitioning from in-person to remote instruction due to COVID-19 has impacted students, their ability to learn in this new context, and the social consequences of online education (Adedoyin & Soykan, 2020; Gillis & Krull, 2020; Godoy et al., 2021; Oliveira et al., 2021; Peacock et al., 2020). Prior to COVID-19, women already encountered major barriers to developing a strong sense of belonging and identity as engineers (Caspi et al., 2008; DeAngelo & Lewis, 2023; Hall & Sandler, 1982; Walton et al., 2015; Wilson & VanAntwerp, 2021; Wilson et al., 2021). The well-known challenges that women in engineering must navigate (Aycock et al., 2019; Blackburn, 2017; DeAngelo et

al., 2023; Leaper & Starr, 2019; Wilson et al., 2021), coupled with the effects of the emergent transition to online learning, have likely compounded, creating an even more arduous environment for women who have experienced this disruption (Means & Neisler, 2020).

However, Gopalan et al. (2022) indicated that students who possessed a strong sense of belonging pre-pandemic experienced lower anxiety and were safeguarded from symptoms of depression due to COVID-19; yet the authors also found that underrepresented students entered the pandemic with lower sense of belonging, underscoring the importance of establishing belonging for students who experience additional barriers. The work of Marler et al. (2021) demonstrated a positive correlation between academic motivation and sense of belonging. Yet, the authors also found that when students experienced pandemic-related adversity, the relationship between these two factors was negative. Stress is detrimental to academic success (Abramson et al., 1980; Araki, 2000), and college students were experiencing heightened anxiety due to COVID-19 (Marler et al., 2021). As belonging can counteract the negative consequences of anxiety (Gopalan et al., 2022), developing a better understanding of how women engineering undergraduates at different points in their academic careers experienced belonging during the pandemic could enhance efforts to support this often marginalized group within this context.

As COVID-19 becomes endemic and institutions of higher education seek a “return to normalcy,” the implications of COVID-19 on the student experience continue to have a ripple effect. Therefore, acknowledging the effects of the pandemic on students who attended college virtually for a significant period will be essential for those working with this population. This remains especially important for underrepresented students who must already overcome barriers that majority students do not (i.e., women in engineering). Doing so will require institutions of higher education and those individuals working within colleges and universities to address the ways in which students were negatively affected; therefore, enhancing women engineering students’ sense of belonging remains critical. Additionally, because 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 educational contexts that may continue to impede women’s abilities to enhance their sense of belonging. Moving forward, it is important to consider the effects of virtual learning and its potential to either exacerbate or ameliorate longstanding inequities in higher education.

Methods

This IRB reviewed and approved study took place at a research institution in the Mid-Atlantic region of the United States. We conducted focus groups aimed at understanding the lived experiences of women engineers as they transitioned from their first year to their engineering majors in their second year. Specifically, the focus groups were used to understand students’ experiences and the challenges students face as they transitioned into their engineering majors. COVID-19 and virtual learning was not the focus of the protocol, and no mention was made of the pandemic in

the questioning route. Thus, the discussion of and representation of COVID-19 and virtual college emerged organically from participants. The focus groups were developed based on Krueger and Casey's (2015) purposes and methodology for applied focus group research, which encompasses how to plan your groups, develop your protocol, and analyze and report on your results. Applied focus groups are designed to create a more natural environment for discussion about how a group of people perceive a situation. This method is a more appropriate choice than individual interviews as it allows participants to have a highly planned conversation that is much closer to an organic exchange that they might have with the same individuals.

Sample

In this study, we used seven focus groups conducted in March 2022 with 21 women and one non-binary student, the majority of whom were white (see Table 1), who at the time of data collection, were engineering majors in their third or fourth college year. All the participants' sex assigned at birth was female.¹ Krueger and Casey (2015) stress the importance of homogeneity among participants and the need to allow for enough variation among group members for contrasting viewpoints. We achieved this with our women engineering students through our diversity in majors as

Table 1 Participant demographics

Pseudonym	Race/Ethnicity	Virtual Terms	Year in School	Engineering Major
Mackenzie	White	3–1st Year/2nd Year	3rd Year	Bioengineering
Olivia	White	3–1st Year/2nd Year	3rd Year	Chemical and Petroleum
Ashley	White	3–1st Year/2nd Year	3rd Year	Chemical and Petroleum
Bailey	White	3–1st Year/2nd Year	3rd Year	Electrical
Anna	White	3–1st Year/2nd Year	3rd Year	Industrial
Laurel	Black	3–1st Year/2nd Year	3rd Year	Mechanical
Taylor	White	3–1st Year/2nd Year	3rd Year	Mechanical
Alexa	White	3–1st Year/2nd Year	3rd Year	Mechanical
Tina	Southeast Asian	3–2nd Year/3rd Year	4th Year	Bioengineering
Michelle	East Asian	3–2nd Year/3rd Year	4th Year	Bioengineering
Christina	White	3–2nd Year/3rd Year	4th Year	Bioengineering
Natascha	White	3–2nd Year/3rd Year	4th Year	Chemical and Petroleum
Claire	White	3–2nd Year/3rd Year	4th Year	Chemical and Petroleum
Emily	White	3–2nd Year/3rd Year	4th Year	Civil and Environmental
Trinity	White	3–2nd Year/3rd Year	4th Year	Computer
Sabrina	White	3–2nd Year/3rd Year	4th Year	Environmental
Caroline	White	3–2nd Year/3rd Year	4th Year	Environmental
Erin	White	3–2nd Year/3rd Year	4th Year	Industrial
Kalea	Multiracial	3–2nd Year/3rd Year	4th Year	Industrial
Maria	White	3–2nd Year/3rd Year	4th Year	Mechanical
Mila	East Asian	3–2nd Year/3rd Year	4th Year	Mechanical
Laura	White	3–2nd Year/3rd Year	4th Year	Materials

¹As the student information system at the research site collects data on sex versus gender, sex assigned at birth was used to identify potential participants. However, participants were asked to self-identify their gender after consenting to engage in the study, which accounts for the singular non-binary student.

well as class years. For fourteen of the students, the abrupt change to virtual learning due to COVID-19 occurred during the second semester of their second college year (March 2020) and continued throughout their third college year (2020–2021). For the other eight, the shift to virtual learning began in the second semester of their first college year and continued throughout their second year.

Data Collection

Following guidelines from Krueger and Casey (2015) in developing a questioning route, the arc of the focus group was specifically designed to elicit stories of challenges and successes students had during their transition into their engineering major in their second college year. The focus groups began with an acknowledgement from the lead facilitator that although students do not often talk about it, many experience challenges as they transition into their majors. Students then were invited across a series of questions and activities to share about their challenges and how they overcame them during their second college year. The activities the women engaged with included the creation of journey maps (Kelly & Kortegast, 2017), in which they highlighted memorable experiences as students in engineering. Through this exercise, participants were asked to represent the arc of their experience in engineering within their specific major and were encouraged to draw and write about anything that was particularly important or memorable to them. Then, in a separate exercise, the participants documented at least three challenges and resolutions, which we refer to as good/bad cards, they experienced during their second year as they transitioned into their engineering major (i.e., the height of virtual learning related to COVID-19 for some of the participants). Finally, participants were asked to write a letter to a past version of themselves focused on an internal challenge they had faced and how they overcame it. There was no direct discussion of COVID-19 present in these letters, likely due to the specificity of the instructions for this part of the focus groups. As such, data from this activity was not included in this study.

Data Analysis

We engaged in analysis as a sequential process in our planning and execution of the groups and as a continuous process that began at the conclusion of the first focus group and continued through the process of developing the full manuscript, consistent with Krueger and Casey's (2015) approach. Individual members of the research team divided up the focus group transcripts and engaged in preliminary coding and analysis. We began Krueger and Casey's process (2015) by first engaging in open coding of the transcripts and then in focused coding as it related to belonging. As data from the focus groups were analyzed, the authors began to identify themes and together developed a coding table (Table 2). As the purpose of the data collection was to better understand how students experience the transition into their engineering majors, codes did not initially focus on COVID-19 or virtual learning, although sense of belonging issues in relation to COVID-19 emerged organically through data analysis. From there, we developed memos related to the sense of belonging for each focus group as well as for each participant (Krueger & Casey, 2015). In the memos

Table 2 Focus group analysis coding scheme

Social Support	Curriculum	COVID	Realization	Identity	Priorities
<i>Challenges related to making friends & finding social support.</i>	<i>Course & content-related challenges.</i>	<i>Ways in which COVID impacted experience.</i>	<i>Realization relating to past academic or social struggles.</i>	<i>Experiences relating to varied identities.</i>	<i>Competing priorities, challenge of balancing multiple commitments.</i>
Isolation/loneliness <i>feeling of sadness due to lack of social connections</i>	Faculty support (or lack of) <i>faculty providing knowledge, resources, or emotional help</i>	Difference between online and in-person class <i>comparison of experience in varying modes of education</i>	Imposter syndrome <i>feeling unworthy of belonging in engineering</i>	Engineering identity <i>personal feelings around place in Engineering</i>	Overwhelmed <i>pressure of having too many commitments</i>
Peer support (or lack of) <i>friends providing knowledge, resources, or emotional help</i>	Challenging coursework <i>demanding class/struggles with course material</i>	Isolation/loneliness <i>feeling of sadness due to lack of social connections</i>	Gender discrimination <i>experience of being treated unfairly because of gender.</i>	Gender identity <i>personal feelings around gender</i>	Transition <i>process or period of shifting from one state into another</i>
Family support (or lack of) <i>family providing knowledge, resources, or emotional help</i>	Peer comparisons <i>comparing to peers/classmates academically</i>		Mansplaining <i>experience where men interrupt or correct.</i>	Racial identity <i>personal feelings around race</i>	Balance (or lack of) <i>ability to give equal effort to multiple commitments</i>
Clubs & activities <i>influence of clubs & activities on experience</i>	Campus resources (or lack of) <i>university services or staff providing knowledge, resources, or emotional help</i>		Failure <i>Feeling of not meeting an expectation or accomplishing a goal</i>	Other identities <i>personal feelings around identity not related to one of the above roles</i>	Stress <i>feeling of emotional tension, challenge, or demand</i>
Community <i>feeling of belonging amongst a particular group</i>	Confidence <i>feeling of self-assurance related to participant's abilities, or experience</i>		Defiant commitment <i>I will make it through because I am supposed to be an engineer.</i>	Visible under-representation <i>recognition of being the "only one" or one of a few</i>	Strategy <i>discussion of tactics or planning to accomplish something or overcome barrier</i>

related to the groups, and for this study we focused on the extensiveness of the discussion of COVID-19 among participants, and in the individual memos on frequency and intensity of discussion as we began the process of developing analytic themes (Krueger & Casey, 2015).

Members of the larger research team, broken up into smaller groups, then engaged in a day-long coding exercise where transcripts and all artifacts were reviewed and evaluated. The exercise was organized as a round robin where each member of the team reviewed and coded every artifact. A working spreadsheet was created for team members to identify and track the salience of COVID within participants' experiences, which served as a basis for the development of Table 3. Ongoing discussions occurred throughout the day to reach consensus around themes and interpretations. This process of balancing frequency and extensiveness is important in making inferences from data (Bazeley, 2013). In engaging in the analysis of the artifacts, and in keeping with the approach of Krueger and Casey (2015) for focus groups, we focused

Table 3 Summary of COVID salience by year

Participant Pseudonym	Year in School	COVID Impact on Engineering Experience		
		Discussed explicitly in transcript?	Represented on journey map?	Represented on good/bad cards?
Mackenzie	3rd	N	Y	N
Olivia	3rd	Y	N	Y
Ashley	3rd	Y	Y	Y
Bailey	3rd	Y	Y	Y
Anna	3rd	Y	Y	N
Laurel	3rd	Y	Y	Y
Taylor	3rd	Y	Y	Y
Alexa	3rd	Y	Y	Y
Overall COVID Salience for 3rd year women:		87.5% (7/8)	87.5% (7/8)	75% (6/8)
Tina	4th	N	N	N
Michelle	4th	N	N	N
Christina	4th	Y	N	N
Natascha	4th	N	Y	Y
Claire	4th	Y	N	N
Emily	4th	N	Y	Y
Trinity	4th	Y	Y	N
Sabrina	4th	N	Y	Y
Caroline	4th	Y	Y	N
Erin	4th	Y	Y	N
Kalea	4th	Y	Y	Y
Maria	4th	N	N	N
Mila	4th	Y	Y	N
Laura	4th	Y	Y	Y
Overall COVID Salience for 4th year women:		57.1% (8/14)	64.2% (9/14)	35.7% (5/14)

first on perception of importance (or not) related to COVID-19 in the student’s representation of their journeys, challenges, and successes, and then on the intensity and specificity of the representation and its relation to the purposes of the study.

Positionality

We entered this work committed to building belonging among women engineering students in their majors. However, we recognize that our own positionalities can create biases, influence participants’ willingness to share particular experiences, or affect our interpretations of the data (Merriam & Tisdell, 2015). First, none of the authors are engineers, although one is a STEM insider as a faculty member in biology and the other two possess a wealth of knowledge regarding the experience of women in STEM as scholars of gender within the context of these disciplines. Second, although members of our larger research team who participated in data collection with us share identities with our participants of Color, the whiteness of the lead focus group facilitator (lead author) could have impacted the data shared with us by participants of Color. Third, as individuals, we were not unaffected by COVID-19,

and as such, our own experiences with and the effects of the pandemic on our own lives could have impacted our interpretation of the data.

Trustworthiness

We sought to establish trustworthiness using both method and researcher triangulation. Method triangulation, or the use of multiple methods, was achieved through focus group transcripts, journey maps, and good/bad cards (Lincoln & Guba, 1985). Researcher triangulation was achieved as nine team members were involved in data collection, six of whom also participated in data analysis. The research team engaged in peer debriefing through involved conversations regarding study design, data collection, and analysis. An audit trail was also created, which included fieldnotes generated during focus groups by two team members whose sole responsibility was to document participant body language, and comprehensive notes collected during data analysis that capture significant excerpts of data and highlight artifacts related to COVID-19's impact on participants' sense of belonging in engineering. The research team also engaged in the process of coding and recoding, with various team members reanalyzing data at different points across time. Method triangulation and the audit trail resulted in a thick description which is desirable in seeking to establish trustworthiness (Merriam & Tisdell, 2015).

Findings

Participants described various ways that the pandemic affected their sense of belonging. Students who were remote through their second year focused on the feelings of isolation and loneliness that they experienced; whereas students who were remote through their third year leaned into relationships that were established prior to the pandemic, using the physical separation from campus as a time for reflection. However, we also found that participants who had challenges prior to COVID-19, regardless of class year, experienced a heightened intensity of these issues and additional barriers during remote instruction.

“Very isolating, you feel very alone”: Remote Experiences in Second College Year (first year in engineering major)

Given that the entry process into engineering majors at many institutions occurs in the second year, second-year engineering students essentially experience a sort of double transition, as they must first acclimate to campus culture and then again, as they move into their academic programs. In the case of the second-year students in this study, shifting to remote instruction without a strong sense of belonging in their major, and in many cases, a lack of community, created additional obstacles that participants had to navigate. The compounding of these multiple barriers produced an especially arduous environment for women who exist within a disciplinary culture in which they are a minority and as a result, confronted with a myriad of challenges that their men counterparts are not.

For participants whose first year on campus was cut short and then engaged in remote learning during their second year, this physical absence from the institution removed opportunities to build peer relationships in the major, which could have enhanced students' sense of belonging. As an example of the problems that online instruction posed for second-year women engineering students, Ashley described that it was "challenging for me to [get to] know people." Much like other students noted, Ashley also shared that because she was a social person and enjoyed working in teams, "going into the online classes and not knowing anybody [made it] hard to connect names with faces." Ashley reinforced this sentiment on her good/bad cards, writing "Adapting to an online class format especially while also learning difficult material. Not knowing anyone in my major due to the onset of the pandemic/zoom classes." Ashley summarized these feelings of isolation in the focus group with an example, stating that:

Zoom, it was extra hard. It felt like my professor was really far away. He wouldn't even turn his camera on sometimes and nobody in the class would turn their camera on, so it would just be names. And I only ever knew everyone by names. Not having like a group or a community at all that you can ask questions to, combined with everything being on Zoom, and not even seeing people's faces - very isolating, you feel very alone.

Online instruction therefore exacerbated the isolation that Ashley was already experiencing due to a lack of opportunities to connect with peers in person. Similarly, much like many of the participants, Olivia echoed Ashley's sentiment, stating:

I just feel like if there's one thing that I missed a lot in that sophomore year that could have helped me, it was forcing social interactions, which I know was hard because we were all trying to adjust to the COVID guidelines. But just in general, that definitely would've helped.

Participants in this study who were in their second year and transitioned into engineering during the height of COVID-19 (the 2020–2021 academic year), as Olivia's experience highlighted, had limited opportunities to make friends in classes, which impacted their experiences in coursework. This lack of peers to rely on for academic help or social support was in direct contrast with the experience of the participants who experienced remote instruction in their third year. Taylor, like the other participants in this class year in the study, shared a similar experience, stating: "I was online first semester [of sophomore year, but living at "Mid-Atlantic U"] and then I stayed home the second semester [of sophomore year] because it was just completely not worth it to even be in [Mid-Atlantic] city. Now I feel like I don't know anybody in my classes." This lack of community was reinforced on Taylor's good/bad cards where she described the consequence of the challenge as "Crippling loneliness – I was online for all my classes, so I had no friends in my major." The absence of a network of peers within engineering that Ashley, Olivia, and Taylor experienced underscores the significant consequences of isolating for safety's sake on second year students' sense of belonging.

Even for students who thrived in the time that they were on campus for their first year, the shift to online learning posed negative effects on their sense of belonging in the second year of their academic careers. For example, in her focus group, Bailey shared:

I had a horrible transition into my sophomore year, actually. I really excelled my freshman year. I loved what I did. I found a home in [Mid-Atlantic U.] and in engineering, I thought it was my place. Then COVID happened....

Like the other second-year women in the study, Bailey’s experience reinforces the negative impact that the pandemic and resulting separation created for students who were forced to shift to remote instruction during their second year.

Not only were students’ social lives and ability to build community negatively affected by the pandemic and shift to online courses, but their sense of belonging as it relates to their majors also suffered. As an example, Mackenzie created her journey map as a line graph to show how her confidence levels shifted as she endured various experiences (Fig. 1). She wrote on it: “BioE[ngineering] classes are hard. Taking them online makes it even harder. I don’t know how to study. I’m struggling with my mental health and I’m doubting my ability to be an engineer.” The academic challenges that Mackenzie experienced, coupled with the inability to connect with peers for support, negatively affected her sense of belonging in the major.

Students were also impacted by the ways in which student and professor relationships had to adapt because of the pandemic. For example, Anna found it difficult to connect with her engineering professors, which meant that when she struggled academically, she hesitated to reach out to them for support. She stated:

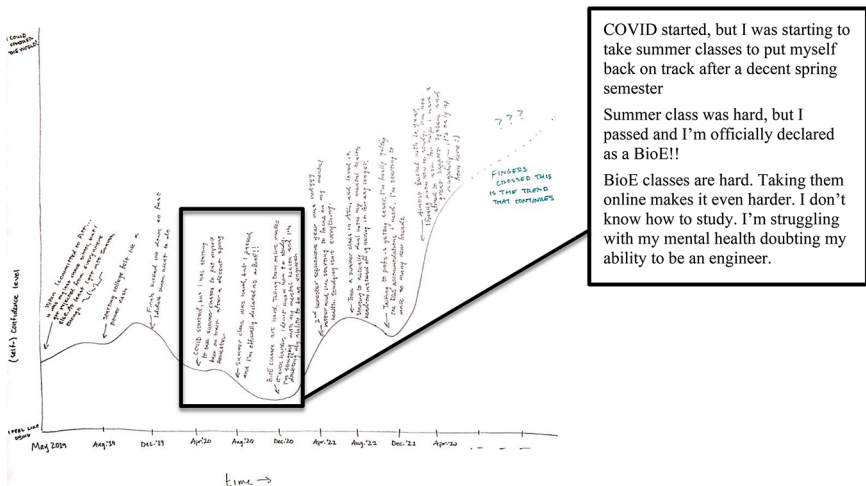


Fig. 1 Mackenzie’s journey map

My second year started online, so it was a little bit harder to go to office hours because it's a little awkward. It's just you guys [student and professor] in a Zoom meeting together. I don't know, it's just awkward.

Although a sense of belonging within the major may not have mitigated students' less than favorable feelings about virtual interactions with professors, a stronger community of support within engineering and amongst their peers may have created additional venues for assistance.

Given that the second year is hallmarked by students' entry into their majors in engineering, a strong sense of belonging is essential for navigating this additional transition. However, in the case of women who were remote in their second year of study, the shift to remote instruction, which occurred prior to establishing community and belonging in their academic major, created additional barriers, which for women in engineering, compounded on top of the other gender-based challenges they face (Caspi et al., 2008; DeAngelo et al., 2023; Hall & Sandler, 1982; Walton et al., 2015; Wilson et al., 2021).

“Making the Most of the Challenge”: Remote Experiences in Third College Year (second year in engineering major)

Participants who had nearly two full years on campus before being “sent home” at the beginning of the pandemic highlighted COVID-19's significance on their experiences in engineering at lower rates, as indicated in Table 3. These students experienced the transition to and consequences of online instruction much differently than their peers who were in their second year. These third-year students leaned into the relationships that they had cultivated prior to the onset of the pandemic. In fact, many of the third-year students in this study noted that the time away from campus allowed them to focus on academics and solidify their commitment to engineering. For example, as visible on Christina's journey map (Fig. 2): “COVID, fewer comparisons to others; more time to reflect on what is best for me.”

Caroline elaborated on the idea that the pandemic offered a break to be intentional and reflective, sharing how being removed from the campus environment forced her to focus on academics, which benefited her.

I guess the big turnaround is [that] even though COVID was not necessarily the best thing for all of us, it really helped me focus on academics and... Then I made the honor roll and got an internship for that summer.

On her journey map (Fig. 3), Natascha described how although “everyone has to deal with it [COVID-19], I'm going to make the most of this challenge.” She went on to describe how she and friends in her major “work[ed] together to do well despite remote learning.” As Natascha had already built peer connections in her major, she had classmates to lean on for academic and social support.

Not only were relationships with classmates that were established before the pandemic beneficial to women's sense of belonging within engineering, strong connections to faculty also positively impacted students' experiences. For example, Kalea

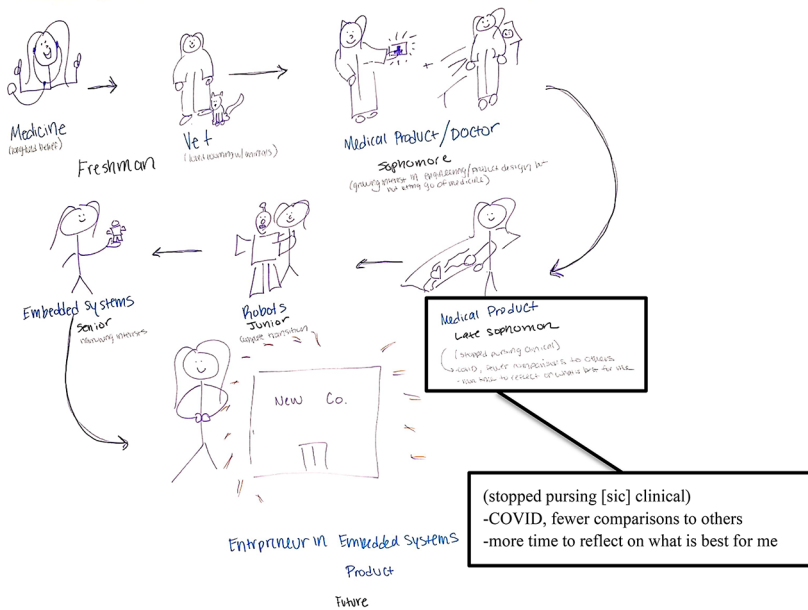


Fig. 2 Christina's journey map

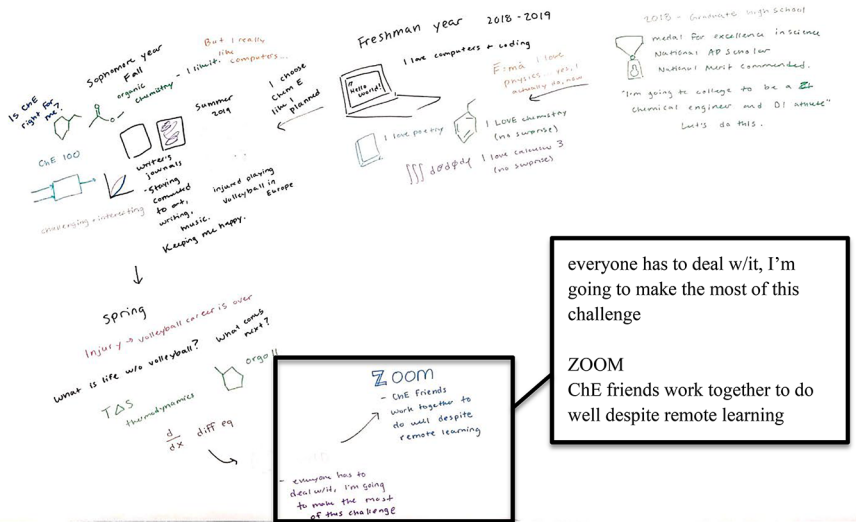


Fig. 3 Natascha's journey map

discussed her “overwhelmingly positive” experience with engineering professors pre-pandemic so that when COVID-19 necessitated a shift to online learning, the strength of Kalea’s relationships with professors made it easy for her to visit virtual office hours. She stated in the focus group:

I think it was less intimidating for me to go to office hours virtually just because it was more of a like, ‘okay, I’m already on my computer. I might as well just click the button rather than having walk down the halls and try to look for their office.’

Compared to second year students who struggled to attend virtual office hours because of their limited sense of belonging in the major and lack of a relationship with their professor, Kalea and other third year students were not deterred by remote environments in their efforts to connect with faculty. The experiences of the third-year students highlighted in this section, especially as contrasted with that of students who were in their second year, demonstrates the disparate impact that the level of belonging students possessed prior to the pandemic had on their remote experiences. For third year students who entered online instruction with established relationships with both peers and faculty and a strong sense of belonging within the major, they perceived remote coursework and the physical separation from campus as an opportunity to reflect and more deeply focus on academics. Third year students did not have the same social concerns as second year students; in fact, many, like Natascha, described working *with* their established friend group in engineering throughout the period of pandemic-necessitated online learning to support one another.

“I wasn’t equipped:” COVID-19 Exacerbated External Challenges Irrespective of Class Year

While participants’ experiences in remote learning contexts had patterns by class year, students who encountered external challenges prior to or during the pandemic, regardless of class year, faced a heightened intensity of these barriers and accompanying challenges to belonging. For example, Mila, stated that “When COVID hit, a lot of the small scale or internal racism that I and my peers were experiencing started to become more serious.” The discrimination that Mila faced prior to the pandemic, coupled with new levels of it with the onset of the pandemic forced her to question some of her diverse peer relationships and commitment to the institution and college of engineering, indicating that established friendships, in some cases, were the source of Mila’s stress.

Some students were unaffected by broader issues like those that Mila endured and instead returned home to difficult living environments. As Caroline presented on her journey map (Fig. 4): “COVID - moved out of dorm, lost support system, unstable home, struggled to focus on mental health.” In describing this section of her journey map in the focus group, she noted that it wasn’t until she moved into her own apartment after returning home from campus, that she had a “safe space, work environment,” indicating that her family home was an unstable location for her to reside.

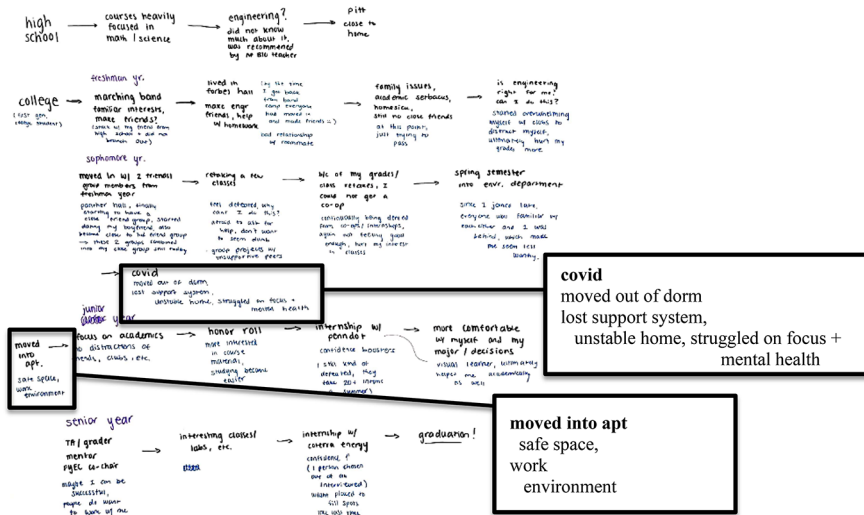
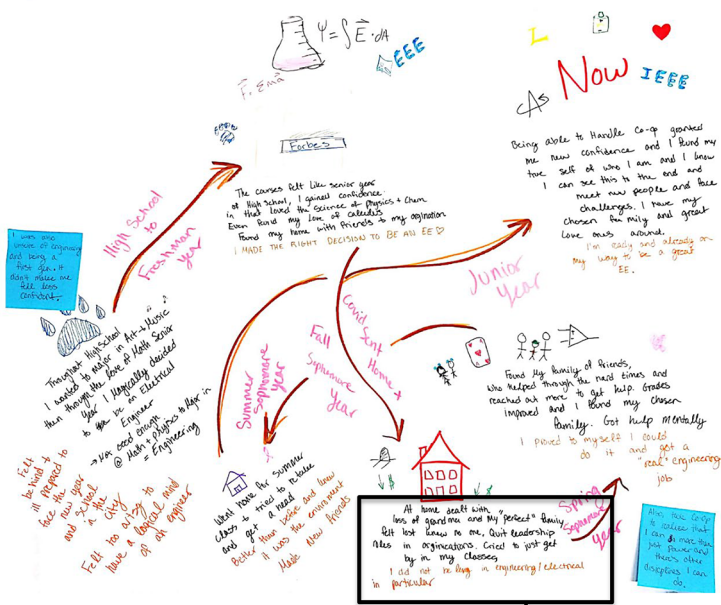


Fig. 4 Caroline’s journey map

For students like Caroline, campus was a physical location that was safe, and the social connections created there were a secure community that they could rely on when challenges arose. And, although Caroline indicated that her campus community was a safe space for her, it could not combat the challenges she experienced at home. However, once she was able to move out of her family’s house and into a safe physical location, and without the social distractions of friends and clubs, she was able to focus on academics and enhance her study skills, which resulted in her making the honor roll. However, the precarious home environment she had to navigate posed challenges to her ability to successfully engage in remote instruction.

Unfortunately for a number of students like Caroline, their return home as they engaged in remote coursework was the cause of challenges that significantly impacted their ability to be academically successful. The issues were sometimes so severe that peer connections and a strong sense of belonging could not counteract the challenges. For example, while Bailey’s home situation was not as precarious as Caroline’s, she was still forced to navigate several significant issues and loss that inhibited her ability to successfully transition into her major and perform well academically (Fig. 5). The challenges began with the death of her grandmother and continued with her parents’ financial issues and subsequent divorce. As a second-year student with limited community at Mid-Atlantic U, Bailey attempted to manage these profound changes in her life with few friends, feeling lost, and trying “to just get by in my classes.”

Bailey’s challenging home life and family breakdown not only negatively impacted her ability to perform well academically but were also intensified by her lack of community and sense of belonging in the major.



At home dealt with loss of grandma and my “perfect” family felt lost knew no one, Quit leadership roles in organizations. Cried to just get by in my classes

Fig. 5 Bailey’s journey map

In sum, the effects of COVID-19 on women engineering students’ sense of belonging were dependent on the class year that participants’ academic careers were interrupted, with the pandemic intensifying year-specific challenges associated with particular transitions like transitioning into the major, building and maintaining peer connections, and managing challenging disciplinary coursework. However, students who had transitioned into their major pre-pandemic were able to lean into pre-established relationships and use the time away from campus as a period of reflection, in some cases, strengthening their sense of belonging. Yet, students throughout class years who were affected by external challenges like systemic racism and unstable home environments experienced a heightened intensity of these barriers, in some cases, compounded by the lack of belonging at the institution and within the major.

Discussion

Results from this study contribute to our understanding of the effects of COVID-19 on students who possess social identities that put them at risk of additional barriers and further marginalization. Our purpose was to understand how remote learning during COVID-19 affected the overall experience and sense of belonging of women

engineering students, and in what ways this differed based on the point at which virtual learning was introduced into their college experience. Results demonstrated that the shift to remote instruction significantly impacted women's experiences, with established peer relationships and connections to the major or the lack thereof related belonging in different ways throughout class years, underscoring the need to disentangle research on threats to and opportunities for belonging (Allen et al., 2021). An important distinction emerged through our analysis between students whose second year, and thus entry into their engineering major, was interrupted by the pandemic and those who had already transitioned into the major and were engaging in upper-division coursework remotely.

For participants who had their entire second year punctuated by remote learning (i.e. the point at which students in this study were taking the first courses in their engineering major), it greatly impacted their ability to connect with peers and build relationships with faculty, had negative impact on their academic performance, and intensified deficits in sense of belonging in their majors and the institution. These issues negatively impact academic performance, persistence, and retention (Hurtado & Carter, 1997; Perez, 2020; Schaller, 2009). Without the opportunity to build social and academic connections, second year students were devoid of support structures that would have benefited them when they experienced challenges. These breakages in belonging in the second year then forced women to tackle these belonging tasks later in their college career while simultaneously addressing challenges to belonging that traditionally occur in later years during the undergraduate experience (Correll et al., 1997; Gardner & Van der Veer, 1998). These compounded challenges create cumulative disadvantages for women as they navigate these belonging interruptions, as well as gender-related challenges that their men counterparts do not experience.

Participants who had their entire third year affected by COVID-19 described entirely different experiences than second year participants. Specifically, students who had integrated into the major and had established peer and faculty relationships during their transition to their major in the second college year (pre-pandemic) tended to see COVID-19 as a reflection point or "reset" that allowed them to solidify their commitments to their discipline. Even for some third-year students who experienced challenges during the pandemic, the community they had built prior to the onset of remote instruction allowed them to lean into that community to assist them in overcoming challenges such as managing difficult upper-division coursework and working in groups remotely on projects. However, for other women regardless of class year who encountered external challenges prior to or during the pandemic faced a heightened intensity of these barriers during remote learning, some of which could not be mitigated by a strong sense of belonging (Hausmann et al., 2007; Hurtado & Carter, 1997; Perez, 2020). Issues like unstable home environments, overt racist incidents related to the pandemic and racial reckoning in the summer of 2020, and expectations on some students around supporting family and siblings while engaged in online instruction were exacerbated by COVID-19 and the emergent shift in course delivery, creating cumulative obstacles for these participants (Adedoyin & Soykan, 2020; Gillis & Krull, 2020). Previous research has also demonstrated the effects on students of balancing academic responsibilities amidst crisis situations and the many tasks competing for their attention during a time of heightened stress. Students in

many cases experience increased anxiety, which, in similar emergent circumstances (e.g., natural disasters) has resulted in post-traumatic stress disorder, negatively impacting self-efficacy and academic performance (Gillis & Krull, 2020; Godoy et al., 2021).

While the pandemic may be a distant memory for some, the effects on those who were enrolled in higher education during the height of COVID-19 remain. Our findings highlight that the remote instruction necessitated by the pandemic did not singularly impact women engineers' experiences negatively; rather, it also provided an opportunity for some who had already found belonging in their engineering majors to reflect on established relationships and focus on addressing a variety of issues that they were unable to do when coursework occurred in person. Although this benefit of remote instruction for some women could have been a result of fewer campus distractions (e.g., student clubs, opportunities to socialize), there is a possibility that it perhaps was less stressful to engage in academic spaces without pressure to perform their gender in a highly masculine disciplinary environment (DeAngelo & Lewis, 2023). In fact, recent research demonstrates that women who work remotely experience fewer microaggressions, have more psychological safety, and improved career outcomes (Thomas et al., 2023). However, for those second year women who perhaps did not have a community of peers and had not yet transitioned into their majors, navigating the barriers that women in engineering are already expected to overcome (Aycok et al., 2019; Blackburn, 2017; Leaper & Starr, 2019; Wilson & VanAntwerp, 2021) along with the threats to belonging introduced by the pandemic resulted in an even more challenging environment for them. The results for how second year women are impacted is an important contribution to the limited body of literature on the critical role of belonging within students' transition into their academic major.

Implications for Practice

Remote learning appears to be a remaining feature of higher education post-pandemic, and on many campuses is actually increasing (Dhawan, 2020; Singh et al., 2021). Given the lingering presence of online instruction and the findings from this study, instructors and other curriculum developers should consider ways to facilitate peer relationships and establish community and belonging for students enrolled in online instruction. Additionally, faculty leading remote courses should seek out ways to build relationships with students, as findings indicate that strong connections between instructors and students can help to mitigate challenges. Peacock et al. (2020) highlighted the value of facilitating belonging for online learners, indicating that it can serve as a strategy for enhancing students' experiences, academic performance, and persistence. The importance of establishing belonging in the major necessitates particular attention be paid to the second year in engineering when students are transitioning into their academic program. Ensuring that students seamlessly integrate into their major, regardless of its delivery format, can encourage a strong sense of belonging (Ahlqvist et al., 2013). This study demonstrates the potential negative implications for women who did not establish belonging in their engineering discipline in this transition year.

The current prevalence of online learning notwithstanding, the consequences of the pandemic for those who were enrolled in higher education at the time of the emergent shift to remote coursework remain and must be addressed, especially for those who are most vulnerable. Given that women in engineering already experienced additional barriers that their men counterparts did not prior to and after the pandemic (Caspi et al., 2008; DeAngelo et al., 2023; Hall & Sandler, 1982; Walton et al., 2015; Wilson et al., 2021), the additional challenges caused by COVID-19 are yet one more hurdle that women must overcome. Students who endured interruptions to their in-person collegiate experiences may continue to feel the effects on their sense of belonging, not just in their major of choice or institution of higher education, but potentially in their engineering careers as they graduate and move into the workforce (Dhawan, 2020; Gillis & Krull, 2020; Godoy et al., 2021). In fact, despite earning 24% of engineering bachelor's degrees across the U.S. (National Center for Science and Engineering Statistics, 2023), women comprise only 11% of the entire engineering workforce (National Science Board, 2014), with nearly 40% of women who earn degrees in engineering either leaving the profession entirely or never even entering the field post-graduation, often due to climate issues (Fouad, 2014). As such, assessing and addressing any belonging uncertainty for women in engineering is imperative. Efforts to mitigate the potential attrition of women out of the engineering field could not be more important.

Implications for Research

Despite the wealth of research that is emerging on the impact of COVID-19, more studies are needed. In particular, both within engineering and other STEM majors with persistent equity gaps in outcomes, additional studies are needed that specifically explore the effects of remote instruction on transitioning into particular majors, consequences on disciplinary satisfaction, and any impacts on post-graduation career selection. In this work it is important to consider not only if these impacts are positive or negative, but how they might be associated with belonging activities in particular class years that were conducted remotely. Given the paucity of research on the importance of belonging *as* students transition into their academic majors, further studies are needed on this topic to explore and confirm the criticality of facilitating belonging in engineering throughout the transition process, especially for underrepresented students. Additionally, scholarship has yet to even begin to examine the longer-term effects of COVID-19 and remote instruction on student outcomes, much important work is needed in this area. A limitation of our study was a lack of racial diversity among our participants; studies that focus specifically on women of Color in engineering and their experiences are needed. Finally, in future studies focused on sense of belonging, based on results from this study on how threats to belonging differed by college year, we add to Allen et al.'s (2021) call on the need to better disentangle both threats and opportunities to belonging throughout the lifespan of the undergraduate experience.

Conclusion

Belonging is critical for all students, but even more so for women as they experience gender-related challenges within engineering that a strong sense of belonging might mitigate. This study underscores the importance of belonging, especially as women transition into their engineering majors. Regardless of whether acceptance and transition into the major occurs in the first or second year, belonging is critical for women in engineering in persisting through this transition and any associated challenges. Although another interruption to in-person instruction like COVID-19 is unlikely, findings from this study both contribute to the limited literature on belonging as students transition into their major and provide meaningful insights into how the pandemic and subsequent shift to remote instruction has and may continue to affect students. Given students and institutions' proclivity towards online education, further understanding of the consequences of such approaches is imperative.

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