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Exploring Gendered Experiences of High-Achieving Undergraduate Women in Mathematics

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Abstract

Women's experiences in mathematics have been a research topic for a long time. We expand on that research to ascertain whether women's experiences in mathematics have shifted in the past four decades. Through thematic analysis of semi-structured interviews, we highlight the experiences of two undergraduate women in mathematics. The findings suggest that mathematics spaces continue to be inequitable based on gender and remain predominantly male dominated. Women may feel the need to position themselves as gender-neutral friends and minimize their gender or center other experiences, such as mathematical ability, to construct a sense of belonging in mathematics. There is a specific need to dismantle the view of mathematics solely as a matter of ability and understand that gendered experiences exclude women from the STEM fields. We argue that women's negotiation of their gender as a signifier of belonging in mathematics reinforces patriarchal dominance in the field, where women are discouraged from embracing their gender and acknowledging their roles as "doers of mathematics." This study emphasizes the continued need to address gender in mathematics research and provides implications for equity in mathematical fields through the voices of women students.

Introduction

In the 1970s, there was much discussion concerning sex differences in mathematics achievement (Fennema, 1974; Fennema & Sherman, 1976; 1977) and what later came to be categorized as gender research in mathematics education (see Damarin & Erchick, 2010; Esmonde, 2011; Goldberg et al., 2023; Leyva, 2017). Research on the gender gap has indicated nuanced findings concerning how men and women perform in mathematics, with men in many cases outperforming women (Organisation for Economic Cooperation and Development, 2019). However, a meta-analysis report by Lindberg and colleagues (2010) challenges these findings. Their study investigated 242 studies on gender differences in mathematics. Across these studies, gender differences favoring boys were found to be negligible (d = 0.05). They also identified a small gender difference in complex problem-solving that favored boys. Their study provides compelling evidence that in high school, there are few statistically significant differences in performance by gender when considering problem type and content. More recently,

Leder and Forgasz (2018) conducted an intriguing analysis of mathematics content and gender differences in the 2015 Trends in International Mathematics and Science Study (TIMSS). Their study showed that in several countries, girls outperformed boys across several math content domains, including algebra, geometry, and data display/analysis.

Recent data from the United States indicates that women are more likely to graduate from high school and attend college (National Center for Education Statistics, 2022). However, even when women are more successful throughout their schooling, there remains a disparity between women and men in their participation in STEM fields as well as their salaries. According to a report by the Pew Research Center (2018) titled *Women and Men in STEM Often at Odds Over Workplace Equity*, men in STEM make $15,000 more on average than women. Data shows even more significant disparities for Latine and Black women, who earn around $33,000 less per year when compared to men. In 2021, according to the National Center for Science and Engineering Statistics (NCSES, 2023), even though women make up 51% of the total population of the United States, they occupy only 35% of STEM positions. These percentages are even smaller when we look at women faculty. Women account for 31% of all full-time faculty in mathematical sciences, with only 15% holding tenure and comprising 26% of full-time tenure-eligible faculty in math departments that grant doctoral degrees (Golbeck et al., 2019). This exclusion of women in mathematics and salary disparities prompts us to direct our attention to the continued investigation of women's experiences in college mathematics before they enter the workforce.

It is not new that mathematics education researchers have adhered to social movements that call for gender equity and social justice (Fúnez-Flores et al., 2024; Hanna, 2003; Kokka & Cody, 2024; Myers et al., 2023). As in any other field, research on gender in mathematics education aims to end gender oppression (Ataide Pinheiro, 2023; Cox & Ataide Pinheiro, 2024; Leyva, 2017). Between 1970s and 1990s we saw a boom in gender (and/,) sex research in mathematics education. More recently, researchers argued that less focus has been placed on issues of gender in mathematics education research. For instance, Lubienski and Ganley (2017) observed that while gender research has gained prominence in other fields, it has somewhat waned in popularity within mathematics education. They arrived at this conclusion after a thorough review of articles published in the *Journal for Research in Mathematics Education*, revealing that only 5% of articles published since 2000 address issues of gender and sex, often in a peripheral manner. While this observation holds for one of the top-tier journals in the field of mathematics education in the United States, it does not accurately represent the broader global landscape of gender and sexuality research. An up-to-date compilation of all publications by the International Commission on Mathematical Instruction (n.d.) illustrates a different perspective. Between 1970-1979, 12 pieces were published as journal articles, book chapters, or books related to gender and sexuality in mathematics education. This number increased to 60 pieces between 1980-1989, 102 pieces between 1990-1999, 125 pieces between 2000-2009, 140 pieces between 2010-2019, and 85 pieces from 2020 to the present when the list was published. This data highlights a consistent growth in publications related to gender and sexuality over the decades. However, it is noteworthy that there has been a shift in focus, with only nine pieces since 2000 explicitly concentrating on women's experiences in mathematics. This shift of gender research focus limits our understanding of contemporary trends emerging from the experiences of women in mathematics education (Lubienski & Ataide Pinheiro, 2020). Therefore, this paper aims to address the need for continual examination of issues of gender in

mathematics and mathematics education (Becker & Hall, 2023). In particular, we are interested in foregrounding whether, after so many efforts to fulfill the promise of gender equality and equity, women have experienced a difference in the mathematical fields, from which they have historically been excluded (Agarwal, 2020; ; Yeh & Rubel, 2020), leading to feelings of isolation (Herzig, 2004; Johnson, 2011), invisibility (Gholson, 2016), and a sense of not belonging (Herzig, 2010; Solomon, 2007). In particular, this study examines the experiences of high-achieving women in mathematics. This paper primarily investigates the experiences of two women majoring in mathematics to reveal how they experienced undergraduate mathematics in the early 2020s. The research questions guiding this study are:

1. What are the experiences of two undergraduate women studying mathematics at a Midwestern predominantly White institution in the United States regarding gender visibility?
2. What gender-related strategies emerge from these students' experiences in mathematics?

Theoretical Framework

Gender and sex are often conflated constructs, making it difficult to distinguish one from the other (Butler, 1990; Kersey & Voigt, 2021). Defining these terms depends on the lenses we use to understand the roles that stereotypes, differences, discrimination, and equity play in our social selves. However, for a long time, mathematics education researchers have not been able to theorize gender adequately (Esmonde, 2011). This lack of theorization solidifies fixed binary perspectives that make the assumption viable that there are only two sexes (male/female), aligned with two genders (girls/women and boys/men) that must follow the assumptions of normativity (Ataide Pinheiro, 2022). Additionally, the challenge of researching social identities (including gender) in mathematics arises from the potential harm to students and the risk of reinforcing stereotypes (see Gutiérrez, 2008; Ladson-Billings, 2006; Martin et al., 2017; Willey & Ataide Pinheiro, 2019), depending on how research findings are framed. An example of this is research that solely focuses on differentiating boys' and girls' mathematical achievements without providing the necessary context for understanding these differences, which can present findings that favor boys and place girls as incapable of doing mathematics. When such research is disseminated, outsiders (girls/teachers/media/researchers) may not understand that this gender inequity results from the gender system, particularly within mathematics. Instead, they may view this inequity as a problem with girls who cannot "do math" as well as boys (Mendick, 2005).

The authors of this study view gender as a socially constructed and fluid apparatus (Butler, 1990; Esmonde, 2011; Nguyen et al., 2022), distinct from sex and sexuality (Ataide Pinheiro, 2022). This approach to understanding gender is informed by a post-structural orientation, which posits that absolute truth is unattainable (Crotty, 1998). As elucidated in the work of Foucault (1980), reality is constructed through the interplay of power and language, and knowledge is not a static entity waiting to be uncovered. In line with the post-structuralist perspective, Derrida (1981, as cited in Mertens, 2014) remarked: "the poststructuralist position deconstructs text, meaning that the reader bears the responsibility of critically engaging with the text as an intervention, grappling with multiple layers of meaning" (p. 9). In the interplay of power and language are discourses that create meanings for our understandings of gendered experiences. Gutiérrez (2013) described the importance of post-structuralist theoretical tools to develop the discourses used to theorize critical mathematics education. According to her, the

way individuals see themselves and the world is created by the political struggles they go through as they negotiate discourses (Gutiérrez, 2013, p. 43). Gutiérrez (2013) defined discourses as "more than talking words. Discourses include institutions, actions, words, and taken-for-granted ways of interacting and operating...Discourses can be thought of more like paradigms which we operate" (p. 43). In a post-structuralist analysis of gender through discourses, there are more than singular meanings and truths for gendered experiences. By extension, through discussions, assumptions, and perspectives, gender becomes a discourse within mathematics, intertwining with the meanings of mathematics and who can or cannot do it. Therefore, gender influences how people interact and feel a sense of belonging in mathematical spaces and determines who are the participants and "doers of mathematics."

As Leyva (2017) discussed, gender is a "dynamic social construct performed differently across contexts and individuals" (p. 398). This idea of gender performativity is drawn from Queer theory perspectives (a post-structural theory), such as Butler's (1990) work, which considered gender a "stylized repetition of acts" that varies across times and places and is pre-established by a set of social meanings. Since gender is not fixed, a precise definition is unreachable. We recognize that gender goes beyond being solely a social construct. As Kendi (2019) argued that race is a *power construct*, we believe the same applies to gender. *Gender* is a power construct created systematically to control individuals in society. Gender, sex, and sexuality are viewed in this study as a combination of the construction of the socialized self (Mendick, 2005). Therefore, this study foregrounds students' voices as a tool to uncover their gendered experiences and self-construction in mathematics. Our theoretical understanding of gender supported open-ended questioning in this study and an inductive approach (Thomas, 2003) to construct meaning regarding the gendered experiences of our study's participants in mathematics.

Literature Review

For many critical scholars, the question of women's exclusion from mathematical fields has an easy answer. Research has shown that biological characteristics are inconclusive regarding whether men's and women's brains point to differences in cognitive strengths or weaknesses (Ceci et al., 2009). Furthermore, other studies have pointed out that sociocultural and political influences on how women have been treated in society affect women's formation of their mathematical identities (Leyva, 2017; Llewellyn, 2009). In mathematics education, these embedded social norms subtly shape teachers' practices and perceptions (Zhou et al., 2023). Research has pointed out that women still lack confidence in mathematics from an early age because they learn that femininity has no space in the STEM fields (Ataide Pinheiro, 2022). There is also research that shows elementary school teachers endorsing stereotypes concerning girls in their classrooms, such that they do not regard girls as mathematics doers as they view boys, unless they perceive girls working harder and behaving better than the boys in their classrooms (Robinson & Lubienski, 2011). Therefore, endorsement of math stereotypes depicting women and girls as less capable, by others including peers and parents, can influence women's experiences in mathematics (Lubienski & Ganley, 2017), including not supporting them to create a positive mathematics identity (Robinson-Cimpian et al., 2014). In addition, societal stereotypes of women not being regarded as mathematics doers have consequences for women not choosing to go into the STEM fields (Buck et al., 2020).

Looking closely at women's experiences, the authors of this paper have seen in research the harsh consequences of discriminatory socialization on women's experiences in mathematics. Research has shown that women feel isolated, oppressed, excluded, and not belonging, among other things (Gholson, 2016; Herzig, 2004, 2010; Solomon, 2007). Some research shows women's brilliance in mathematics; however, it is often by resisting oppression (Joseph et al., 2017; Walker, 2017). Therefore, researchers have argued for the importance of continued investigations into gender issues in mathematics education (Lubienski & Ataide Pinheiro, 2020) because, unfortunately, gender matters. As long as we are unable to map women's experiences in mathematics and understand how to dismantle the oppressive systems that create and perpetuate stereotypes, hindering women from participating in STEM fields, we will be unable to create equitable experiences for women in mathematics.

Essential for this study's literature review are the findings regarding women's gender-related experiences in undergraduate mathematics. In the most recently published literature review on gender and mathematics by Becker and Hall (2023), they reported that only eight publications concerning the lived experiences of undergraduate students were available between 2020 and 2022. Two articles from their review are particularly relevant to this study. First, Hall and Robison's (2020) study, which focused on the perceptions of first-year and final-year undergraduate students regarding university mathematics departments, yielded noteworthy findings on gender-related issues. Their research indicated that first-year students perceived faculty members as supportive, with no reports of differential treatment based on gender. However, final-year students, especially women, displayed a heightened awareness of the declining representation of women in math classes during the program's later years. Women students even demonstrated the ability to discern gender ratios in these courses, a level of awareness not shared by their male counterparts. Moreover, final-year women had encountered gender-related situations where men doubted their mathematical abilities. As a result, these final-year women internalized the pressure to excel in mathematics, which, in turn, hindered their engagement with the discipline. Secondly, Reinholz et al. (2022) found that in inquiry-based mathematical classes, professors engaged with students in gendered ways that potentially had a negative impact on women in these classes. Additionally, they observed that men made more contributions in inquiry-based classes, and women's participation was linked to their performance (Becker & Hall, 2023). Reinholz et al.'s (2022) and Hall and Robison's (2020) findings point to two relevant issues in mathematics: (a) women's achievement is connected to gender discrimination in mathematics, and (b) women's representation declines in undergraduate mathematics as students advance in their degrees.

Another area of research that is tightly connected and relevant to this study concerns women's sense of belonging in mathematics. Solomon's (2007) article presents important findings regarding belonging and women' experiences in undergraduate mathematics. Solomon found that first-year women in mathematics, differently from men, rejects wanting to belong in mathematics when they do not understand the mathematical concept being presented. These conditions further marginalize these women in mathematics. In another study, Rodd and Bartholomew (2006) emphasize how undergraduate mathematics women draw upon their childhood memories of excelling in mathematics to establish themselves as mathematically special and high achievers in mathematics. By doing so, women self-identifying as special demonstrates the various ways these women choose, or choose not, to belong in mathematics. Rodd and Bartholomew make a compelling case in their paper that is particularly relevant to our study. They called for new ways of being in mathematics to be recognized as mathematical. This

call motivated us to continue exploring how women find a sense of be(long)ing in mathematics.

This literature review reports research findings regarding gender in mathematics education research. The literature not only tells a story of how historically oppressed individuals have been excluded from mathematics fields compared to their CisHet White male counterparts but also highlights that those who still choose mathematics do not experience the field equitably. It often requires them to employ strategies to establish a sense of belonging within the field. Therefore, a continued need exists to understand women's experiences and the oppressive forces and systems in mathematical spaces that may hinder their equitable participation in mathematics fields.

Methods

The findings reported in this study come from a more extensive study that investigated the experiences of individuals in mathematics regarding their life stories and their construction of themselves as doers of mathematics (mathematicians). This research was conducted at a large research institution in the Midwestern region of the United States (pseudonym Reed University). Initially, the first author emailed the mathematics department at Reed University requesting if they could share a flyer calling for research participants. At that point, we were interested in understanding the experiences of different individuals in daily mathematics. Seven individuals showed interest in participating in the research through the dissemination of emails by the mathematics department. These individuals included three Queer-identifying men, one straight-identifying man, and three CisHet-identifying women. All the participants were White.

The participants were invited for a 1-hour, in-person, individual, semi-structured interview with questions focused on their experiences in mathematics, covering the following topics: feelings about mathematics, experiences taking undergraduate mathematics classes, feelings of belonging in their undergraduate program, perspectives on advancing into graduate mathematics, beliefs about stronger mathematicians, thoughts about why people decide to pursue undergraduate mathematics, ideal undergraduate mathematics students, impressions of mathematics professors, perceptions of changes in their program, memories from high school mathematics, and reasons people give up pursuing an undergraduate degree in mathematics. During the interviews, none of the questions explicitly inquired about gender. When designing the interview questions, we included gender as one of the covert categories of interest. Therefore, our questions were designed to bring the participants' most pertinent experiences and beliefs regarding mathematics and their mathematical degrees to the forefront. Nevertheless, gender did emerge as a relevant construct in the experiences of two students, as they consistently framed in nuanced ways their experiences in mathematics in relation to gender. Throughout the analysis, we observed that gender played a different role in how these two undergraduate women experienced and viewed mathematics. Therefore, we decided to focus the analysis of this paper on the stories they shared.

All interviews were audio recorded, transcribed, and analyzed using MAXQDA (a qualitative research software). Initially, the first author transcribed the interviews. Then, the authors independently coded the interviews using inductive coding (Strauss & Corbin, 1990). Subsequently, the authors met to discuss the coding of the interviews and developed the themes discussed between the two participants' experiences analyzed in this paper through

thematic analysis (Braun & Clarke, 2006). This process involved categorizing pertinent transcript segments into categories initially derived from post-structuralist theories. In line with the post-structuralist perspective, which deconstructs text as readers critically engage with it as an intervention, grappling with multiple layers of meaning (Derrida, 1981), we repeatedly explored these categories and their interconnections. This iterative exploration revealed the complexities within the study participants' responses concerning representation and belonging in mathematics. Rather than challenges, through a post-structural approach, the authors could engage with one another's understanding of the themes and arrive at strong agreement in terms of the meanings present in the transcripts. These intricacies are presented in the findings through illustrative quotes and their respective analyses. Particularly, two major themes and one subtheme were identified: Theme 1) Strategic Ways of Protecting Sense of Belonging, Subtheme 1.1) Limitations to Strategies for Belonging, and Theme 2) Gender (In)Visibility in Mathematics.

In this paper, we highlight the voices of Gail and Ellie (pseudonyms). It is important to note that although the experiences discussed here contribute to our understanding of mathematical fields and the discourses women foreground about them, they do not indicate all women's experiences within such spaces. We employed strategic essentialism as an approach to interpreting these issues. As defined by Gutiérrez (2002), strategic essentialism is "the process of intentionally categorizing people based on socially defined traits for the purpose of achieving higher (equity) goals" (p. 154). The discourses shared are excerpts of these students' actual experiences within mathematical fields and society.

Participants

The first participant, Gail, is a white CisHet upper-class woman who grew up in the Midwest of the United States. She was a junior student when the interview took place and majored in mathematics (applied mathematics) and economics (econ). During her interview, she did not raise many gender-related issues. When she did bring up gender to discuss her experiences in the mathematics department, she did not emphasize it as a significant factor in shaping her experiences in mathematics. Moreover, if she mentioned gender in an experience, she quickly moved away from it, as if it had little impact on the experiences being discussed. The second participant, Ellie, is also a White CisHet woman from the Midwest who came from a working-class family. Ellie was a senior mathematics student when this study took place, and she was applying to PhD programs in pure mathematics. Throughout her experiences, Ellie saw her gender as a fundamental factor producing many experiences of injustice and inequity in mathematics spaces.

Authors' Positionality

We share similarities and differences with the two participants' experiences analyzed in this study. The first author is a Queer man of color who grew up in Brazil and has dealt with issues of gender performance discrimination throughout his life. The second and third authors identify as women of color and have experienced gender discrimination in the STEM fields. All three authors have earned undergraduate or graduate degrees in STEM disciplines (mathematics and engineering). These three authors share many experiences with Gail and Ellie, which

puts them in a position to empathize with the experiences the two participants shared. For example, all three authors have encountered instances where STEM fields were perceived as exclusionary based on their gender and/or sexual identities. The first author has observed the persistent notion of mathematics as a value-free discipline where sexual identities are deemed irrelevant. Meanwhile, the second and third authors have personally faced continued biases and discrimination associated with being women in STEM.

Findings

In analyzing the data, we noticed that Gail and Ellie overlapped in how they discussed the visibility of women's presence in mathematics. However, their construction of belonging in mathematics and their perceptions of their gender in those spaces differed. Thus, the analysis of findings is presented through the two major themes foregrounded in Gail's and Ellie's experiences: (1) how a sense of belonging can be constructed through distancing from gender and drawing on narratives of ability and (2) the (in)visibility of women across mathematical experiences.

Strategic Ways of Protecting Sense of Belonging

Ellie and Gail utilized strategic ways to construct and protect their sense of belonging, including distancing themselves from their gender and drawing on their perceptions of mathematical ability. For instance, Gail strategically navigated her sense of belonging by distancing herself from her gender when considering the gender dynamics in spaces where she was often the only woman. When asked what strategies she used to navigate moments when she felt she didn't belong, she shared:

> I think making actual friendships with the guys in my class has been helpful because if you noticed the distinction, like I'm the only girl, there's only guys, then it is a bit weird. But if you're like, oh, no, that person is my friend, it's less of a heavy distinction and I feel welcome in a spot even though I'm not exactly like the rest of these people.

For Gail, she felt that it was weird if she distinguished herself as the only girl in her class. By distancing herself from her gender as the only woman and instead positioning herself as just a friend in those spaces she was able to construct her sense of belonging as someone who was welcomed. Gail recognized that there was a distinction when she was the only girl when there were only guys. But as a friend, and not a girl, she was able to feel exactly like the other students, namely men, in her mathematics courses. This distancing from gender was one way in which Gail was able to craft a sense of belonging for herself.

In contrast, Ellie found it difficult to make friends with men when she was the only woman. She stated "[in] most of my classes, I'm the only girl and so that makes it weird to make friends. And then, you know, they'll have like, this guy friend group sort of thing, you don't really want to, like, intrude on it." Like Gail, Ellie recognized that it was "weird" being in spaces where she was the only girl, but where Gail felt she could belong if she just saw herself as a friend, Ellie felt like she would be an "intruder." For Ellie, when men had their "guy friend" groups, she didn't feel like she could be a friend within those groups because she was not a guy.

Instead, Ellie constructed her belonging by drawing on narratives of the ability and exceptionality of "math people." When asked why she chose to pursue a degree in mathematics, Ellie stated:

> I was always good at math. And I liked it...and I was always advanced in my math, sort of...I just would do well, in my classes. I was comparatively [good]. I would talk to other people about it. And they'd be like, Oh, I hate math. I don't understand it, that sort of thing. And for me, I just clicked. I knew it was something that was kind of, uncommon, I guess.

When probed about whether she believed there are certain people who are and aren't good at math, she stated:

> I think especially from working in the math Learning Center, there's some people who just won't get it and just can't get it. And there's just something that their brain just doesn't work that way. And it would take much more effort for them, than it would for me to do something.

While it is clear from her interview that Ellie believed that women shouldn't be excluded from mathematics, her sentiments that there are certain people that have innate capabilities and aptitudes toward mathematics created a tension for how to construct belonging. Ellie constructed a space of belonging by aligning herself to the "uncommon" few—those that get it—due to her ability to have mathematics "just click." She belonged because her brain worked the right way to engage with mathematical concepts more easily and she didn't struggle like others might. The ways that Ellie constructed belongingness in mathematics with narratives of ability were reinforced through validation from performance and messaging from teachers:

> I attribute my wanting to do math to my calc 2 teacher. And there's a certain moment when I didn't raise my hand. One day we were supposed to work on a problem by ourselves. And I got the right answer. And I had it on my paper, but I wasn't gonna say anything about it. But he came over and saw that I had it written on my paper, and he was like, wow, okay, good job, no one else got that sort of thing. And then goes to the front, he's like Ellie, can you explain how to do this problem. And since I don't seek the recognition by raising my hand and saying the answer, I'm not comfortable doing that, I needed him to come by and tell me you're doing a good job and you get this and that's good. I needed that push.

Again, here we see that Ellie positioned herself as someone who "got right answers" and was able to understand the problem when "no one else got that sort of thing." Normally, Ellie would not have raised her hand, but because she had the right answer and she was able to figure it out in a way that no one else had, she was positioned as someone with mathematical ability and someone with intellectual authority who could stand at the front and explain the problem to others. The validation she received from her teacher solidified her sense of belonging due to her ability to be good at mathematics, even if she was a woman.

Similar to Ellie, Gail created a space of belonging for herself by constructing mathematics as spaces for smart people, not necessarily attributable to gender, and the messages she received about her own ability. She stated:

> It goes back to an experience I had in elementary school where I was pulled out of class, and [given an] exam. Since I did well, I was taught, oh, you have a mind for math, nobody else does. And there's that instant . . . I think I was very lucky to just magically have done well. I just happen to have the brain that they required for math at that time. Because I just happened to have whatever I needed, I was able to continue in math being told, yes, I can do this. Whereas everybody else almost was like, oh, you're

> struggling with math, we'll just put you with all the other students who are struggling, there's no real need to teach you in a different way.

Here, Gail was reflecting on her experience taking a placement exam in elementary school to determine if she would be placed in more advanced math classes. She positioned herself as someone who was able to just "magically have done well" and was affirmed as someone who "happened to have the brain required for math" and wasn't excluded like her peers. Her belonging was constructed around her innate ability and being told that she "had a mind for math," that "nobody else does." She belonged in mathematics because her performance on the exam said she needed to be taught a different way, when everybody else was struggling.

Limitations to Strategies for Belonging

Both Ellie and Gail constructed their belonging in mathematics around mathematical ability. While Gail expressed in some parts of her interview struggles in viewing herself as holding high mathematical ability and even a slower transition into higher-level mathematics, her sense of belonging in mathematics almost never faltered. In contrast, Ellie expressed her belonging as constrained to certain contexts, including those she considered to be less competitive. Moreover, these highly competitive spaces that Ellie did not see as possible for her were spaces only available to those who she presumed had the highest mathematical ability and were predominantly men. Even though Gail and Ellie each constructed a sense of belonging through ability, there was a limited level of belonging that was accessible through these conceptions of ability due to their gender. For example, Ellie's construction of belonging was limited when she recounted her experience in a summer math research undergraduate (RU) program with other students majoring in mathematics from all around the United States. She described her experience as:

> I'd say some, like I've had super negative feelings with like, the second summer research thing I did was last summer…it's one of the more like prestigious ones. And all of the it was half men, half women […] the gender dynamics of the whole program was just awful, like, worse gender dynamics and sort of discrimination I've ever felt. And so kind of by the end of the summer, I was like, I can't do math, it's too hard. Like, again, it's way too hard. And this is not the environment I want to be in.

Ellie explained that while there was gender parity in the participants of the program itself, her overall experience was once that evoked negative feelings for her. Moreover, participation in this prestigious research program did not grant women participants access to a sense of belonging in that prestigious space. That is, despite her achievement in mathematics and high math ability, as credited by her acceptance into the RU program, Ellie was not able to fully attain a sense of belonging in mathematics. In this instance, by doubting her own mathematical ability in that competitive summer math RU program, "I can't do math, it's too hard," Ellie questioned her belonging in prestigious mathematical spaces as she said, "this is not the environment I want to be in."

Ellie's belonging in mathematics was also limited when she spoke about applying to graduate programs. In seeking mentorship from women professors from the summer math RU program, she wanted to know if mathematics would always feel exclusionary for women, due to the experiences she described earlier. Ellie shared

the following response:

> I started asking, like, is this what it's always going to be like? And from a lot of women, the answer was, yes. But also no. If you look for a program that's not going to be super competitive. So, I didn't apply to MIT, Harvard. I know I don't want to be in that sort of environment. They're like, there always will be discrimination and problems with it. And you'll be frustrated.

Here, Ellie understood that highly competitive programs, like MIT and Harvard, would always be discriminating spaces and frustrating environments. Highly competitive programs were places that she didn't want to be in because she did not want to repeat the gendered experiences she had in the RU program. There were limits to the spaces Ellie could fully belong in. In addition, this limited belonging for women in highly competitive spaces was further corroborated when Ellie reflected on the demographic breakdown of the summer program. She shared that "all the men in the program were from MIT, Harvard, Berkeley, [University of] Chicago" and she "was the only one from a state school, and all the [other] women were from small private schools." Again, in Ellie's perspective, the men seemed to be the ones that belonged in the highly visible competitive spaces like MIT and Harvard, whereas women seemed to belong in smaller schools or state schools.

While both women's sense of belonging constructed through their math ability was viable, for Ellie it remained limited due to gender since she could not aspire to belong in the highly competitive spaces that were occupied by mostly men, to whom she attributed, and left unchallenged, higher mathematical abilities. In the following section, we delve into our second theme to illustrate how the need to negotiate a sense of belonging as women in mathematics constitutes broader issues that influence gender (in)visibility and representation.

Gender (In)Visibility in Mathematics

In the previous section, we shared ways in which Gail and Ellie created a sense of belonging in mathematics. However, their ability to protect their own sense of belonging did not translate to how they viewed women broadly as belonging in these same spaces. In addition, the strategies used by Gail and Ellie helped them individually, but it might not apply to all women being able to belong in mathematics. Further, women's (in)visibility is still left unchallenged by these strategies for belonging in mathematics because these individual mechanisms don't challenge broader systems of gender oppression. Across their interviews, they both commented on the disparate representation of women in mathematics and often referenced that they themselves were the only woman in mathematics. When asked if there was an instance where she felt she did not belong in mathematics, Gail spoke of moments when she was either the only girl or one of very few in different spaces. She stated:

> Oh, absolutely. Walking into math club for the first time. At that point, there was one other girl but now I'm the only girl. I think that was a shock […] and well math classes specifically […] I don't feel that out of place. Interestingly enough, most of my math classes are about a 50/50 split between girls and boys. There's less girls usually, but that's just how things are in STEM. I'm doing an econ degree as well, in the econ department, there's a 75/25 split right now, 75% boys, 25% girls, and I'm in a class right now where I'm the only girl in about 15 guys. That's more difficult, honestly, than the math. I feel like in math, if you understand, you understand it right? If I wanted to step up in the math department, I

> could. Whereas in the econ department, I feel like it's weird to be a girl, you know?

When probed to share more, she continued:

> If you're a girl in math, you just have to work a little harder. But in econ, if you're a girl, it's a question of why are you there? So that is like, a slightly different thing. And I think that's why I'm more comfortable with less girls in math because I'm used to that kind of environment in econ. It's unfortunate but there's not much to do at this point.

In sharing her experiences, Gail began by stating that she was initially shocked to be one of only two girls, and now the only girl, in the math club. And while she found that experience shocking, she felt the math classes didn't make her feel that out of place since they were more evenly split "about 50/50 between girls and boys." However, when she expanded to talking about her experiences completing an economics degree, she again signaled the lack of visibility of women in those economics spaces by referencing that "in econ there's a 75/25 split" and she was the only girl in her current class where there were 15 guys. Yet, in her statement, Gail normalized the gender inequities that exist in STEM spaces, stating "that's just how things are in STEM," and added that she was "comfortable with less girls in math because [she was] used to that kind of environment in econ[omics]" where "it's weird to be a girl." While economics and mathematics are different disciplines, we perceive these subjects as complementary, as most branches of modern economics extensively utilize mathematics and statistics. Furthermore, more recently, in the United States, many university departments are beginning to recognize economics as a STEM field (Redden, 2018). We infer that, while women are not prominently well-represented in economics, Gail distinguishes these two fields, using economics as an extreme example of comparison to underscore the invisibility of women in mathematics. The significant difference emphasized by Gail is that in economics, the question is often "why are you here," while in mathematics, women can construct belongingness by "understand[ing] math" (ability) while putting in "a little more effort."

The idea of "unchangeability" and "invisibility" of women in mathematics from the perspective of undergraduate women was further reflected in how Gail described women's representation within the faculty in her departments. Gail stated that her introductory economics courses were taught by women professors and added,

> Yeah, I don't know a single female econ professor […] besides intro level, they are all male. I don't know any intro level [econ] female professor […] she's the statistics professor. That's weird […] There was a grad student who taught me as well. She taught labor economics.

Here, Gail shared the extreme case of women's invisibility in the economics department, where she did not know any women faculty in the economics department. Additionally, her experiences allude to the visibility of women faculty teaching only introductory courses. Instead of other men faculty teaching the economics introductory courses, they were outsourced to a woman faculty member in the statistics department and to a woman completing her graduate studies. Again, Gail points to apparent issues that speak not only of the lack of women's representation since she was not aware of any women professors in the economics department, but also speak to the discrepancies of who gets to be visible as capable of teaching the more advanced courses versus the introductory courses.

Similar to Gail, Ellie spoke to the lack of women's visibility in mathematics and the invisibility of women faculty in her department. When asked what the most memorable aspect of her degree experience was, she spoke of the relationships she built with professors since she didn't feel that she could connect to her peers, who were predominantly men. She stated:

> I've only had one female math professor […] I had [her] my first semester freshman year […] I went to her office hours a few times, and we connected. She wrote me a letter of recommendation for something but it wasn't much beyond that […] She's just encouraging. And, you know, I emailed her about wanting to start a women in math club, and she was like, you know, whatever you want, tell me what you want, like, you need an audience like, these are all my suggestions, but I'm totally on board, like, whatever you want. So I think she's great. But she's also, she's only one, you know, I haven't met any other women professors […] I really think there are like three tenured female math professors here. There's not very many.

Similar to Gail, Ellie's experienced not having many women professors except one during her freshman year. Ellie's response further speaks to when and for which courses, namely freshman/introductory courses, students might engage with women professors. She further highlights that there are not many women faculty, recalling that she thinks there are only three tenured women. Ellie further emphasized this invisibility of women faculty stating:

> I really think Reed University needs to do a better job trying to hire women faculty members, I don't think they are seeking out to do that. And they're not doing a good job of it.

Ellie recognized the lack of women representation across the faculty, and she felt that it wasn't a priority for the University to have gender representation within mathematics spaces since she didn't think that they were "seeking" to hire more women faculty, and the efforts that perhaps had been made were not adequate since they weren't "doing a job of it" as visible in her experiences only having one course with a female professor during her first year of the program.

In response to a different question about her interactions with professors, she once again referenced her visibility as the only woman in her classes.

> It was my second semester freshman year. That was the first class where I was the only girl. There were nine of us, and I was the only girl. There was another girl for the first day, [but] she dropped out […] I've never raised my hand to talk in class. I just don't do that. But with nine people in the class, and me standing out from the other people, he [the professor] would call on me a lot.

Like Gail, Ellie shared several memorable moments that stood out when invisibility of other women led to her visibility as the only woman. By examining Ellie's experiences, we can also draw connections to how the lack of women's presence in mathematics affected her ability to make friends, as she was often the only woman in her academic environment. Her expressive comments that "it makes [it] weird to make friends" as the only woman again show the limitations of belonging in mathematics. Additionally, the hypervisibility of being the only woman in her courses led to her being called on and asked to speak up even though that was not something she would have normally done. In fact, being the sole woman in mathematics class also led to her being perceived as a

representative for all women, which made her a frequent target for questioning from the professor of the class. Ellie further constructed the invisibility of women in mathematics by reflecting on her experience at the RU summer program. In reflecting on that experience, Ellie stated the multiple instances of gender discrimination, which included the ways in which the women were made to feel invisible. She shared:

> The groups were completely gender segregated. When we ended up doing the projects, there were the girl projects, and the guy projects […] We had presentations every Wednesday morning, and we would start timing the amount of time that men talked versus the amount of time that women talked. It was something like 3 hours to 5 minutes. It was that drastic.

While this particular space had more women present and representation was balanced, the invisibility of women was still a salient issue due to the inequitable access to air space when students presented their projects. The percentage of time that women spent speaking when compared to the men was almost negligible, and this inequity was normalized by the mentor faculty in the program. Furthermore, Ellie highlighted how gender segregation by groups occurred naturally, with male students often preferring to work exclusively among themselves, excluding women from their groups. During presentations of research findings, Ellie noted that women's groups were allocated only 5 minutes, reflecting a lack of interest from men students and faculty members in what they had to say about the mathematics being discussed. Conversely, guys were afforded three hours for their presentations, as the professors and other students displayed significant interest in their discussions. These observations underscore that belonging in this program was limited for women who encountered inequitable experiences regarding being heard. While they may be present in these spaces, they are still silenced and made to feel invisible.

These examples speak to the multiple ways in which Gail and Ellie both felt the invisibility of women in mathematics, in relation to their own hypervisibility as the only or one of few women, given the lack of gender representation. When asked what could be done to encourage more girls in a math department, Ellie connected back to the need to have women be more visible in mathematics. She stated:

> Just other women, seeing other women doing math. I feel like having some sort of role model or something like that. Girls in your classes and things like that is encouraging, and makes you feel like you're in the right place, and you don't have to drop out and quit.

For both Ellie and Gaile, the lack of women's presence at both the student level and the faculty level in mathematics was a salient issue. In the previous comment, Ellie began to carve out possibilities for making mathematics more inclusive for women, suggesting that having more women doing math could encourage women to feel like they belong and that they have a right to be visible in mathematics. For Ellie, when women are present and visible, they can provide guidance (role modeling) and encouragement for other women to continue and persist.

Discussion and Conclusion

In this paper, we analyzed the experiences of two women, Gail and Ellie, in mathematics to better understand the experiences of undergraduate women in mathematics. Throughout their interviews, they both constructed a sense

of belonging to make sense of themselves as doers of mathematics, although at times they used different strategies to justify their belonging as women. In doing so, they both foregrounded the (in)visibility of women in mathematics. Moreover, while the invisibility of women in mathematics is not a novel discovery in research exploring women's experiences in undergraduate mathematics, it sheds light on how women navigate their mathematical experiences in light of this invisibility and their gender, particularly how it influences their sense of belonging within mathematics spaces.

For both participants, the ways they made sense of gender played a key role in how they experienced mathematics. Gail distanced herself from her gender to make sense of belonging in mathematics and economics. Her use of economics departments as a counterexample to explain why mathematics departments are not that bad for women was another form in which Gail attempted to navigate women's visibility and belonging in mathematics, specifically by stating that "If you're a girl in math, you just have to work a little harder. But in econ, if you're a girl, it's a question of why are you there? … that's why I'm more comfortable with less girls in math." Gail further recognized that success in mathematics for women is not equitable, stating that she would have to work harder as a woman (Yarkin et al., 1982), but she felt unable to change the systemic gender inequities that exist in STEM fields (Buck et al., 2020). For Ellie, gender visibility in mathematical spaces was extremely significant and undoubtedly informed her sense of belonging. As an honor student since elementary school, Ellie's experiences provided opportunities for her to see herself as a learner and doer of mathematics. Yet, her later experiences made her hyper visible as the only woman in mathematical spaces, creating a point of contention for her due to her gender. While Ellie did not distance herself from her gender in the ways Gail did she still upheld narratives of ability and exceptionality in mathematics (Chestnut et al., 2018; Rattan et al., 2012) to inform her sense of belonging. Yet even though she knew she was capable, she still felt limited in accessing highly competitive spaces because she did not want to experience the level of gender discrimination she faced during her RU summer program with men from highly ranked mathematics programs. This tension with belonging as a woman limited the ways in which Ellie felt capable of fully participating in highly competitive mathematics graduate programs (Leyva, 2017). Ellie and Gail's strategies for negotiating their sense of belonging in mathematics highlight the persistence of patriarchal dominance within the field, where women often feel compelled to downplay their gender and identity as both women and highly successful doers of mathematics.

In terms of (in)visibility of gender in mathematics, Gail and Ellie highlighted that in their experiences, mathematics was still dominated by men. Gail's comparative observations between her experiences in mathematics and economics related to the lack of visibility of women, including women professors teaching higher-level (non-introductory) courses, was most likely informed by the systemic and historical exclusion (Yeh & Rubel, 2020) of women faculty in mathematics departments (and mathematical intensive courses) and those who pursue tenure. This historical and systemic gender inequality has led to mathematics departments being dominated by men (NCSES, 2023) and to the strong likelihood that more men faculty are fully tenured (Golbeck et al., 2019). Additionally, due to departmental structures that often give course preference to tenured faculty compared to those who are tenure-track junior faculty or non-tenure track (e.g., lecturers, clinical, of practice, etc.), the men faculty in Ellie and Gail's department(s) may have benefited from this structure and privileged status to teach their preferred higher-level courses, leaving the women faculty to teach the introductory courses.

Given that this study discussed the gendered experiences of two high-achieving students from the Midwestern United States, further studies are needed to better understand how successful women with varied identities and backgrounds create spaces of belonging and navigate mathematics. Future studies must consider issues related to the intersectionality of race, ethnic identity, linguistic practices, and socioeconomic status (SES). Gail and Ellie were both White women, and throughout their interviews the topic of race and SES was never brought up as an issue within mathematics departments. Yet, there were differences in how they constructed belonging in relation to mathematical ability. Where Gail (upper-class) never questioned her ability, for Ellie (working-class) she felt limited in prestigious spaces. Researchers have voiced that intersectionality matters, and it produces differentiated experiences in society, especially for those who have multiple marginalized and underrepresented identities (Hong et al., 2023).

In addition, intersectionality studies have shown that the experiences of a White woman in society are very different from those of a Black woman because a Black woman experiences not only sexism and misogyny, but also racism (Crenshaw, 1991; Hooks, 1994). At the intersection of targeted oppression, gender, and race, the experiences of women of color are different and their intersecting identities must be accounted for, especially in the STEM fields (Allen, 2024; Buck et al., 2020). Future studies can investigate if by being White, students like Gail and Ellie naturally have a sense of belonging in spaces, and therefore, gender becomes less important as they can leverage their White privilege to affirm their sense of belonging (Battey & Leyva, 2016).

Gendered experiences continue to shape educational outcomes for students (Lubienski & Ataide Pinheiro, 2020), and with that recognition, we look at the experiences of Ellie and Gail as sites for understanding the necessary shifts required in the field to improve equity within mathematics. Specifically, recalling Ellie's and Gail's observations to the very few numbers of women faculty as well as students they encountered in their undergraduate mathematics courses, visibility of more women is needed to tackle gender inequality in mathematics. Indeed, recruitment of women faculty across all faculty levels, but especially those pursuing tenure-track positions or possessing tenure, should be a priority for mathematics departments as these numbers still favor men faculty. In turn, this visibility of women faculty could support efforts to recruit and retain young women pursuing mathematics degrees as they could see mathematics as a possibility for themselves. However, these efforts to bring more women into mathematics also need to be simultaneously implemented with efforts to improve women's experiences and interactions in mathematics.

Indeed, Ellie's experiences in her RU program and her department urge a need for faculty not only to recognize the lack of women's representation in mathematics but also to become more familiar with practices that are responsive to the specific needs of women. This way, women in mathematics can feel supported in cultivating their sense of belonging. Ellie's isolating experience, seeing the lack of support women students received from the RU program and the lack of interest from faculty to engage with their ideas, speaks to how current faculty and mentorship programs perpetuate women's exclusion in mathematics even when they are physically present. Therefore, addressing these issues in faculty support could enhance women's sense of belonging in mathematics and contribute to more systemic changes in how women perceive and experience mathematics when entering this field.

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