

“If you are good enough, that can transcend the gender stuff”

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Women in advanced mathematics continue to be underrepresented despite representational progress in K-16 mathematics. Existing literature has investigated women’s mathematical identities at the undergraduate level and revealed varying ways women organize their mathematical selves in response to the masculine context of mathematics. In this paper, I expand on the existing identity research about women in undergraduate mathematics to better understand the mathematical identities of women in doctoral mathematics. I discuss themes related to women’s mathematical identities and the cultural discourse of “Women in Math.”

Keywords: Gender, graduate mathematics, identity

Despite improvement in representation at the undergraduate level, women are still underrepresented in doctoral mathematics with only 28% of doctoral degrees awarded to women in 2018 (National Science Foundation, 2021). In addition to inequitable representation, women in doctoral mathematics have experienced overt prejudice, feelings of invisibility, insufficient or negative advising experiences, and a lack of belonging (Herzig, 2004). Furthermore, women’s reports of success are often mitigated by expressions of struggle, bringing into question the quality of their experiences (Ataide Pinheiro, 2021).

The limited research investigating women in advanced mathematics is overwhelmingly focused on understanding the individual factors influencing persistence and attrition (Herzig, 2002a, 2002b; Miller, 2015), with few studies (e.g., Ataide Pinheiro, 2021; Lubienski & Ataide Pinheiro, 2020) focused on the school and societal contexts and their effect on women. Identity research is a potential solution in bridging broader contexts to individual experiences and allows one to reveal the taken-for-granted or status quo that privileges some and excludes others (Darragh, 2016; Gutiérrez, 2013). Identity framing affords researchers the ability to highlight how students “fit into a broader discourse about the politics of language, racism, sexism, and teaching and learning” (Gutiérrez, 2013, p. 44).

Gendered discourses and discourses that create hierarchies of mathematical ability are pervasive in mathematics (Leyva et al., 2021; Mendick, 2006). Mendick (2006) details how gendered identities and practices are produced and reinforced in mathematics classrooms and how certain discourses contribute to the association of mathematics with masculinity. The association of mathematics with masculinity, paired with the idea that mathematical ability is innate, creates an impasse for women who are generally underrepresented in mathematics. At the undergraduate level, mathematics education researchers have taken up the investigation of women’s mathematical identities and their relationship to broader discourses about mathematics and gender, finding that these discourses make developing strong mathematical identities a challenge (Damarin, 2008; Hottinger, 2016; Mendick, 2006; Rodd & Bartholomew, 2006).

Women in undergraduate mathematics have responded to these seemingly incompatible identities of woman and mathematician in several ways. They may explain their mathematical talent while maintaining the feminine identity, and/or distancing themselves from a masculine identity by explaining their mathematical ability as abnormal or special. Alternatively, women may choose to downplay their ability as a result of hard work rather than natural talent, contradicting how they ascribe innate mathematical ability to men (Rodd & Bartholomew, 2006).

Solomon et al. (2016) describe another option in which women may develop hybridized mathematical and woman identities through recognition of and reflection on the contradiction posed by being a woman and mathematician. While these studies have not focused on graduate mathematics, there is no reason to believe these discourses are not shared across mathematical contexts and that women in advanced mathematics face some of the same cultural obstacles in adopting mathematical identities. However, doctoral mathematics also differs from undergraduate study and more research is needed to understand the experiences of women in advanced mathematics.

Building on and expanding the literature, I focus on women doctoral students. My goal is to understand the discursive processes by which women construct their mathematical identities. I investigate how woman doctoral students respond to the discursive label of “Woman in Math.” by answering the research question: *How do women in doctoral mathematics describe being a “Woman in Math?”*

Theoretical Framework

In response to research of women in doctoral mathematics which focuses on individual factors, I adopt the figured worlds framework, in an effort to connect individual experiences to broader societal narratives about what it means to be a woman in mathematics (Holland et al., 1998). Figured worlds are defined as “socially and culturally constructed realms of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (p. 52). As a sociocultural theory, figured worlds assumes a reflexive relationship between social activity and individual development.

In particular, Holland et al. (1998) emphasize that identities are developed through participation in the activities organized by figured worlds, and figured worlds are produced and reproduced through the work of participants. Their definition of identity states:

People tell others who they are, but even more important, they tell themselves and then try to act as though they are who they say they are. These self-understandings...are what we refer to as identities (p. 3).

This conception of identity includes the stories we tell about ourselves and others as well as our behaviors which are influenced by these stories.

Drawing from Vygotsky, Holland et al. (1998) emphasizes semiotic mediation with respect to human activity and identity building. This means that cultural artifacts such as objects, discourses, and even people are ascribed meaning and taken up as individuals structure their identities. Holland et al. (1998) draw connections that equate discourses and artifacts, with both being used as tools for mediation. Others have described discourses as “symbols, signs, artifacts, and other cultural representations” (Reinholz, 2022, p. 37) and a source of individuals’ meaning making and knowledge (Gutiérrez, 2013). Under this perspective discourses do not describe objective truths; they structure our worlds. The parallels between artifacts and discourses help to understand the way broad social narratives occur in daily social interactions and are appropriated by individuals as they develop their identities.

In the context of doctoral mathematics many aspects of the figured world may signify meaning and value and be taken up by women as they refine their mathematical identities. For example, if a student has a prestigious advisor this might elevate their status in the department and lead to more confidence. Other factors such as grades, qualifying exams, social connections, and of course gender may also influence how they view their mathematical selves.

Gender

While the figured worlds framework does not have a particular focus on gender, I take the understanding, based on the literature (i.e., Mendick, 2006), that gender is part of the value-laden context of doctoral mathematics. Furthermore, I take gender to be a social construct that is continually performed and enforced through various cultural and institutional practices (Butler, 1990). This suggests that gender is not innately residing within individuals but is rather something they *do*. Butler (1990) argues that gender is performed through a repetition of norms, gestures, and discourses that present an image of stable identity. This conception of gender destabilizes the idea that masculinity and femininity are essential, fixed categories (as evidenced in Solomon et al. (2016)). However, despite the theoretical understanding of gender as a continuous, fluid performance, there is a societal commitment to a gender binary (Butler, 1990; Wilchins, 2011), which is paralleled in mathematical contexts and evidenced through a gendered hierarchy of mathematical ability (Hottinger, 2016; Mendick, 2006).

Woman in Math

In the process of interviewing and getting to know the participants in this study I realized that the label Woman in Math held more meaning for them beyond their individual experiences. It invoked many responses, some proud, some distancing. It became apparent that there was a larger cultural meaning associated with the label “Women in Math.” Furthermore, all the participants were members of their local Association for Women in Mathematics (AWM), creating a local cultural meaning for them in their department. In retrospect this makes sense considering all the many programs and initiatives taken to increase gender diversity in mathematics at all levels. As such, I consider “Woman in Math” a societal discourse and take it up as an object of interest in this study.

Context and Methods

Southwest University (SU) is a large public university in the southwest United States and is classified as a very high research activity institution. The mathematics department at SU has approximately 200 students enrolled in their doctoral program, with about 15% of students identifying as women. There are approximately 60 faculty, a minority of whom are women. The structure of the program is typical of many mathematics PhD programs in that the first and second years of the program are dedicated to coursework in preparation for three written qualifying examinations, followed by original research.

Participants included five women enrolled, or recently enrolled, in the doctoral mathematics program at SU. The women were selected using a stratified purposeful sampling (Patton, 1990) with respect to years’ experience in the program. This included one woman enrolled in coursework, two women in early research, one woman in advanced research, and one woman taking a leave of absence after completing coursework. Additional sampling criteria included participation in the local graduate chapter of the AWM. Data sources included one-hour narrative interviews (Mueller, 2019) from each of the five participants and a focus group interview with four of the five participants. The focus group and narrative interviews included a range of questions about the participants’ experience in doctoral mathematics. In this report I focus my analysis on two questions – “*What does it mean to be a woman in mathematics?*” and “*How has being a woman shaped your experiences in mathematics?*” The interviews and focus group were transcribed and open coded for distinct, meaningful ideas (Braun & Clarke, 2006). Preliminary results include three themes – *anticipating doubt*, *proving yourself*, and *transcending gender* – and their potential connections.

Preliminary Results

There were myriad responses in response to the questions analyzed. However, most participants expressed some version of the first two themes, anticipating doubt and proving yourself. I include that last theme, transcending gender, despite only two excerpts coded from the same participant as it is closely related to the theme of prove yourself.

Anticipating Doubt

Four of the five participants expressed the idea that people might make assumptions about them because they are women in mathematical contexts. For example, one participant explained:

I also think that a lot of people kind of like do not expect women to be good at maths. Like even in grad school that I think that maybe like in study groups like not maybe taking women seriously or like kind of ignoring what they're saying, because there is kind of an implicit assumption that it's not going to be like, useful or correct.

Here the participant describes her expectation for people to doubt her mathematical ability. She notes different contexts, such as study groups and her phrasing of “even in grad school” implies this an experience she has had in the past and present. Another participant states:

I think that the instant assumption first off, is going to be that I'm not a mathematician at all. And secondly, I have an idea in my head that may not be true, that I'm sort of guilty until proven innocent.

Despite her brief expression of doubt this participant makes a stronger statement, that people will assume she is not a mathematician at all. The latter half of her statement also expresses the idea that people's first instinct will be to doubt her ability. Overall, this was a common experience to most of the participants. Some women also expressed responding to this perceived doubt by proving themselves to be competent mathematicians.

Proving Yourself

Like the previous theme, four of the five participants expressed the need to prove their mathematical ability. One woman said:

I felt like to get someone's respect, you had to usually show you were smart enough. Maybe you're working on a problem set and you figure something out and then maybe people will then start listening to you and including you.

In this excerpt the participant describes having to prove she was smart enough but also that if she did this could lead to her gaining more access to working with others. In this way there appears to be consequences and benefits to proving her mathematical ability. Another participant presents her perspective as more high stakes:

I always felt that I had to be unequivocally better than all of the men in order to be taken seriously... So I always had to have perfect scores, have the best grade in the class, have everything super, super correct because I always felt like if I missed five points on the

exam, if I was a 95 instead of a hundred, then that would be the reason that someone would write me off.

This passage describes a need for perfection in order to be beyond reproach. She expresses that there is no room for mistakes otherwise her credibility will be questioned. Unlike the previous excerpt, this participant explicitly compares her performance to men. This aspect of her response highlights a connection to the previously discussed hierarchy of mathematical ability and the association of mathematics with masculinity. Most of the women who expressed the need to prove themselves did not describe a need for this level of perfection. However, this participant is the only woman who had responses coded as transcending gender.

Transcending Gender

The transcending gender theme captures the idea that if you are recognized as exceptionally good or successful, then you can escape any implications of being a woman in mathematics. Only one participant expressed ideas related to this theme in response to the interview questions. The first time she discusses the mathematical prestige of her advisor as well as her own accomplishments. She explains:

...I think something that I've talked to with one of my friends a lot is that I have a certain, have a lot of good at math privilege, even though I don't have male privilege...my advisor's very impressive and it seems that the results that I have done in my PhD are very impressive. So it seems that, yeah, my advisor's a woman and I think she probably dealt with lots more things than I dealt with, but the weight of her famousness in the field and her good reputation far outweighs any sort of women in math stuff.

Here she acknowledges that her standing as someone who is successful in mathematics allows her a certain privilege that is valuable but distinct from the privilege men have. She offers evidence of her privilege through the status of her advisor and of her PhD results. She goes on to say that her advisor's reputation distances her from any implications of being a woman in math. Later in the interview she revisits the idea when she says "But I have experienced a sense that if you are good enough, that can transcend the gender stuff." In this excerpt she speaks strictly about her own experience. Taken with her previous sentiments about her PhD results and her "good at math privilege" one can get a sense of what it is required to transcend gender as a woman in mathematics. Furthermore, her statements in the previous section about needing to be perfect to be beyond reproach gain new meaning as she explains what the reward is for perfection; she can outperform her position as woman and "other" in mathematics.

Conclusion

Preliminary analysis shows that women often anticipate that their mathematical abilities will be doubted. Additionally, women may respond to this anticipation by working to prove themselves as competent mathematicians. Some women saw proving themselves as a way to gain access to participation in study groups or mathematical conversations. However, one woman expressed that if she proves herself enough, she can escape being a woman in math completely. These themes reflect an awareness and response by the participants that being a woman is a meaningful aspect of their experiences in advanced mathematics.

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