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Women-Identifying Graduate Students' Values of Mathematics Teaching and Learning: Illuminating Sites of Negotiation and Affirmation

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Abstract: Graduate students' values related to teaching and learning are critical in shaping their professional identities and future careers as faculty members. These values encapsulate instructors' convictions about what is important or worthwhile as it relates to mathematics teaching and learning. Research suggests that mathematical discourses reflect and empower dominant masculine values. Thus, we explore three women-identifying graduate students' values related to teaching and learning mathematics to highlight their voices and emphasize ways in which their values align with or challenge dominant masculine values. Utilizing interview data, we found four values across the three participants: collaboration, student-instructor perceptions, humanizing mathematics, and compassion and care for students' wellbeing. We discuss how these values interact with dominant masculine mathematical discourses and the ways in which these values may help foster equitable mathematics pedagogy. We also identified experiences and features of postsecondary mathematics education through which they encountered and negotiated these values.

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Introduction

The values that women-identifying mathematics graduate students hold about teaching and student learning are critical in shaping their professional identities and future careers as faculty members (e.g., Clarke et al., 2013; Austin & McDaniels, 2006). As many graduate students transition from learners to educators, their beliefs and values not only influence their teaching practices but also contribute to the evolving landscape of mathematics education in postsecondary institutions. Given the underrepresentation of women in mathematics, especially in faculty positions (Casad et al., 2021; Kessel, 2014), it is essential to understand the perspectives and values they bring to their academic and professional lives (NSF, 2021). Research suggests that values related to teaching and learning are central to the development of a teacher identity and can profoundly influence career trajectories (Beijaard et al., 2004). For women in mathematics, these values may encompass a commitment to equity, inclusivity, and student-centered pedagogy, which often contrast the content-focused values historically dominant in the discipline (e.g., Hottinger, 2016; Leyva, 2017; McMinn et al., 2022; Mendick, 2006; Reinholz et al., 2019). Understanding these values is vital not only for supporting the professional development of women-identifying graduate students but also for illuminating their values within the dominant masculine mathematics landscape (Leyva, 2017; Mendick, 2006; Street, 2024).

The alignment or misalignment of these values with the traditional expectations of mathematics faculty can significantly impact the career pursuits and retention of women-identifying mathematicians. For instance, research suggests that mismatches between personal values and the prevailing culture of the discipline may foster role conflict, reduced job satisfaction, and a heightened likelihood of leaving the profession (Gardner & Holley, 2011). Conversely, institutions recognizing and supporting diverse values can lead to more inclusive teaching practices, innovative pedagogical approaches, and a more welcoming environment for both students and faculty (Casad et al., 2019). Examining the values of women-identifying mathematics graduate students related to mathematics teaching and learning offers insight into how they challenge or reinforce pedagogical norms and highlights areas of misalignment that could improve inclusivity. In this study, we asked: (1) What did women-identifying mathematics graduate students value about teaching and learning mathematics? (2) How did they encounter and negotiate these values as they navigated postsecondary mathematics education?

Framing and Perspectives

We ground this study within the position that mathematics education is a values-laden space (Adiredja & Andrews-Larson, 2017; Ernest, 2016; Swanson, 2010). Values represent semi-stable convictions one holds about what is important or worthwhile, influenced by both individual experiences and societal factors, such as gender (Bishop et al., 2003; Seah & Andersson, 2015). Research suggests the values imbued within mathematics spaces often reflect dominant masculine values, such as individualism, rationalism, and competition (Ernest, 2003; Leyva, 2017; Mendick, 2006). Therefore, doing mathematics can produce values tension for those unable or unwilling to assimilate into the masculine culture of mathematics (Levya, 2017; Mendick, 2006). This tension can force women to either conform or sacrifice components of their gender identity to be a mathematician (Hottinger, 2016). While a growing body of work interrogates how marginalized students' values contrast with and challenge dominant masculine values in undergraduate mathematics (e.g., Fong et al., 2019; Levya, 2021; Street, 2024), limited, if any, examine graduate students' values related to teaching and learning mathematics.

Seah et al. (2016) operationally define mathematics education values as tools that are "use[d] to define the relative importance of different attributes of mathematics and of its pedagogy" (p. 14) which are "inculcated through the nature of mathematics and through the individual's experience in the socio-cultural environment and in the mathematics classroom" (Seah, 2005, pp. 146-147). For example, research within K-12 mathematics suggests teachers highly value consolidating material in class, problem-solving and investigative activities, and small-group collaboration (Akyildiz et al., 2021; FitzSimons et al., 2000). As one of the only, if not sole, article that focuses on graduate students' teaching values, Schwartz et al. (2022) found that graduate teaching assistants across disciplines (with 8.7% of the sample in a STEM department) most valued higher-order thinking skills in their teaching, including fostering students' written communication, critical thinking, and information literacy skills. Their results also reflect how gender may influence values of teaching and learning mathematics, finding that women GTAs in their sample valued components of ethics and diversity (e.g., adapting course content to reflect different cultures) more so than men, and that this value was associated with higher use of student-centered teaching practices. Given

the highly contextualized nature of values related to teaching and learning mathematics, instructors play a major role in emphasizing the central values in the classroom. While numerous studies consider teachers' beliefs about mathematics education (Francis et al., 2014), we see that very few focus on what teachers value about mathematics teaching and learning. However, instructors' professional values, and their alignment with what they perceive as disciplinary or institutional values, can affect numerous areas, including their academic motivation, professional identity, and ability to adapt to students' learning needs (Chin et al., 2001; Day et al., 2006). Thus, this work considers graduate students' values given the importance of graduate school experiences as professional socialization. We focus on women-identifying graduate students' values to highlight their perspectives in a masculine domain and connect to emerging work challenging exclusionary gendered mathematical discourses.

Building on theories of professional socialization (e.g., Austin & McDaniels, 2006; Tierney & Rhoads, 1993; Weidman et al., 2003), we view graduate students' values related to mathematics teaching and learning as largely shaped by their rich experiences in postsecondary education. Many scholars have examined how the ongoing socialization process during graduate school shapes the beliefs, values, and professional identities of prospective faculty — informing areas across teaching, research, and mentorship (Clarke et al., 2013; Trede et al., 2012; van Lankveld et al., 2017). This socialization process involves graduate students making sense of "how their interests and values fit…within the academy (Austin, 2002, pp. 103-104)", including observing and interacting with faculty, learning by doing, interacting with peers, and reconciling personal ideologies and beliefs about the profession with the everyday realities (e.g., Austin, 2002; Clarke et al., 2013; Trede et al., 2012). Of particular relevance, research illustrates that experiences as TAs and instructors are especially influential for graduate students' teacher identity development (Austin, 2002; Austin & McDaniels, 2006; Olarte et al., 2023).

We leveraged the perspective of professional socialization to make sense of how postsecondary education experiences (e.g., relationships with faculty and advisors, prior teaching and mentoring experiences, etc.) serve as sites for mathematics graduate students to encounter and reconcile values related to mathematics teaching and learning. This may include the processes of reifying their values or countering values in opposition to their personal ideologies and understanding of mathematics teaching and learning, including ways in which values tension arise within dominant masculine mathematical discourses. Prior scholars have illustrated how teachers come to confront and reflect on their professional orientations—including their values and dispositions—through lived experiences that span from teacher education programs to navigating the everyday realities of school cultures (e.g., Altan & Lane, 2018; Seah & Andersson, 2015; Veugelers & Vedder, 2003), often highlighting moments of tension, transformation, and reaffirmation in their professional development. The processes of *affirming* and *countering* we later highlight echo this existing work yet offer a contextually distinct lens that centers how graduate students in postsecondary mathematics education encounter and navigate values through their lived experiences. By identifying and examining these formative experiences, we can better understand how mathematics graduate students, particularly women-identifying students, develop their values related to teaching and learning mathematics and how institutions might support a more diverse and inclusive set of values in graduate mathematics education.

Positionality

We as the researchers want to emphasize that our personal, cultural, and historical experiences inevitably and importantly shape and influence this work. Our identities and experiences both reflect and distance ourselves from the participants, which encourages us throughout our work to engage in individual and collaborative reflexivity processes. The first author is a gay, Filipino-American, immigrant cis-gendered man in his final year of graduate school and the second author is a straight, white, cis-gendered woman working as an assistant professor at a 4-year institution. We both experienced marginalization in graduate mathematics that enabled us to empathize with the participants, while also inspiring us to amplify and share the voices of women-identifying graduate students' experiences that diverge from our own. While we do not share a theoretical mathematics research background with the participants, we both navigated graduate mathematics and mathematics education research through a mathematics education PhD and a mathematics PhD. We also share the experience of learning how to teach undergraduate mathematics in graduate school as aspiring university faculty. Recognizing our positions within this work promoted important criticality when considering ways in which to consistently center the participants' voices and experiences to support more ethical and authentic work.

Methods

Context and Participants

This study was conducted at Spruce University, a large research university in the West Coast of the United States. We used convenience sampling (Miles et al., 2020) to recruit graduate students in the mathematics department. Sixteen doctoral students completed a survey that elicited self-identified/self-selected demographic information and we invited their participation in an interview about their experiences navigating graduate education and pursuing faculty positions; six students participated in this interview. We focus here on the three women-identifying graduate students from this sample: Kayla, Morgan, and Kendall (pseudonyms). Aligning our work with transformative feminist perspectives (e.g., Creswell & Plano Clark, 2011; Du Bois, 1983; Kitzinger & Wilkinson, 1997), we chose to engage with the experiences and values of women-identifying graduate students without any direct comparison to the experiences and values of men in mathematics. Our analytical focus on Kayla, Morgan, and Kendall is not intended to homogenize nor extrapolate to all women in mathematics doctoral programs. While this sample size limits our generalizability, it affords a deeper and more nuanced attention to these three participants' stories. Centering women's experiences in mathematics and illuminating their values is important in its own right.

All participants self-identified as White/Caucasian, researched theoretical mathematics, and intended to continue their careers as mathematics professors. They all had experiences as teaching assistants (TAs) and as instructors of record for lower division mathematics courses. At Spruce University, TAs planned for and facilitated sections (i.e., recitation hours) under the guidance of a faculty instructor. Below, we provide more details about their individual educational backgrounds, research interests, and prior teaching experiences.

Participants' Backgrounds and Prior Teaching Experiences:

Kayla was a first-year doctoral student and was completing her qualifying exams at the time of data collection. She earned a bachelor's and a master's degree in mathematics prior to beginning the doctoral program at Spruce University. During her master's degree, Kayla served as an instructor of record for precalculus and calculus courses. At Spruce University, she served as a TA for terminal calculus courses for non-STEM undergraduate majors. Her research area is in geometric group theory.

Morgan was an incoming fifth year doctoral student and was progressing on her dissertation research in quantum algebra and knot theory. Prior to Spruce University, she earned a bachelor's degree in mathematics and began a PhD program in mathematics at another institution. However, due to significant challenges and barriers, Morgan left the PhD program and worked in industry for a few years. Her passion for mathematics and teaching led her to reconsider returning to academia and applying to other PhD programs – which is how she came to begin doctoral studies at Spruce University. She has extensive experience as a TA, instructor of record, and adjunct faculty for courses ranging from precalculus to introductory proof courses.

Lastly, Kendall was an incoming fifth year doctoral student with a research focus in lower dimensional topology. She earned a bachelor's degree in mathematics and transitioned directly to the PhD program at Spruce University. Kendall has extensive experience serving as a TA for lower division courses, such as calculus, and some upper division courses, such as an introductory proof course and an advanced linear algebra course. She has served as an instructor of record during summer terms.

Data Collection and Analysis

We conducted one-hour semi-structured interviews (Rubin & Rubin, 2011) focused on participants' experiences in graduate school and career pursuits, including their perceptions of the mathematics professoriate, their understanding of mathematics teaching, and their current teaching practices. We analyzed the interview transcripts using Saldaña's (2013) method of pre-coding, first-cycle, and second-cycle coding. We individually engaged in pre-coding by reading through each transcript and identifying any instances that participants articulated values related to mathematics teaching, student learning, etc. The first-cycle coding process involved reading through the transcripts together and sharing and reconciling the codes we established individually during pre-coding. Our second-cycle coding process involved using the first-cycle codes to build themes reflecting participants' values related to teaching and learning mathematics. Throughout this analysis process, we wrote notes and memos (Miles et al., 2020) capturing the progression of our themes and ideas.

We identified four themes reflecting participants' values related to teaching and learning mathematics: *Collaboration*, *Student-Instructor Perceptions*, *Humanizing Mathematics*, and *Compassion and Care for Students' Wellbeing*. After making sense of these four values, we sought to better understand the experiences in postsecondary education where participants encountered and negotiated these values. Employing a narrative inquiry approach

(Creswell & Poth, 2016), we analyzed their experiences as undergraduate and graduate students, paying close attention to the chronology of events, key actors (e.g., faculty), and contextual details (e.g., cohort structures) of their narratives. Then, we discussed themes in their narratives, particularly theorizing and connecting these sites of values negotiation to the four key values mentioned above.

Findings

Recognizing the limited research on mathematics graduate students' values about teaching and learning mathematics, we adopted a descriptive approach to illuminate these women-identifying graduate students' values. These values are not exhaustive nor mutually exclusive, and we observed participants expressing values that traversed multiple themes.

Collaboration

Kendall, Morgan, and Kayla valued collaboration and reported implementing practices that encouraged students to engage with one another, converse with peers, and make sense of the mathematics together. Although some of their reported practices to foster collaborations were similar (e.g., group work during sections), their motivations for valuing collaboration in mathematics classrooms slightly differed. Kendall and Morgan understood collaborative sensemaking with others as elements of instruction that support students' mathematical learning. They considered group work to be beneficial because it afforded opportunities for students to explain their thinking to others and teach their peers. Explaining why she implemented group work, Morgan said, "[The students] best learn by doing and teaching others…I think it's when you work together, and kind of talk about it with your peers, that's probably when you learn the most." Similarly, Kendall shared, "I do think math classes need more group work, because I think it's super important for people to explain how they think about something and compare that to how other people think about it." For Morgan and Kendall, collaboration supported students' learning.

Kayla valued collaboration primarily because it fostered interpersonal relationships among students and allowed her to connect with them. She recognized the advantages of working together on homework, stating, "I think working with other people to solve problems helps. It might not be the best to do it in a classroom setting, but I think outside a classroom works." However, she reported incorporating collaborative activities in her teaching, emphasizing their role in strengthening her relationships with students. She reflected,

> I usually would just say like, "Alright, break up into groups … and I'm gonna just walk around, and I'm going to sit with you guys and have you talk about the problem to me… I always like trying to sit with them at the table and make it a level playing ground."

For Kayla, group work was not only a pedagogical tool but also a way to personally engage with students.

Student-Instructor Perceptions

Another key value centered around how the classroom learning community perceived each other. All participants valued positive portrayals of themselves to students and reported efforts to ensure that students view them as engaging, caring, and prepared. Morgan embraced the perception that professors and instructors genuinely care about their students. When describing the characteristics of successful mathematics instructors, she expressed that "energy level is not necessary, but it helps a lot. I think for a professor who's engaging and who is willing to involve his students as much as possible, who takes the time to get to know the student." She valued students' perceiving instructors as engaging both in their teaching and in their efforts to get to know the students. She further emphasized, "I think those professors are the best, and the ones who you can genuinely tell that they care. That's the truth."

Kayla and Morgan discussed the perception of being organized and prepared as important dimensions of the broader classroom dynamics. Kayla said, "I think being organized is a good one...it adds that level of respectability to where if you're not organized, it just kind of gives off the wrong vibe." She connected students' perceptions of TAs and instructors' preparedness and organization in the classroom to levels of respect. Similarly, Morgan valued providing clarity in classroom expectations. She shared, "I have a very detailed syllabus, I have a calendar up. I think students should know all the dates of the exams and everything, what's expected of them. I think that they know that in my class." These various reflections suggest that participants are actively making sense of how students perceive them in the classroom.

Interestingly, we also found participants valued students' engagement because it supported their connections with the students. Kendall shared, "I got to know [my students] really well, and they were super chill kids." She elaborated saying,

> I had a really great group of students. They wanted help, they wanted to learn, they wanted to do well. They were motivated. I didn't have any students who just refused to show up to things and refused to participate.

Kendall recognized how students' efforts and motivation mediated easier and more enjoyable connections with her students. While participants specified the importance of these perceptions, their desire to build positive relationships with students was deeply intertwined with their values of humanizing mathematics and demonstrating compassion which we expand on below.

Humanizing Mathematics

Kendall, Morgan, and Kayla all shared pedagogical practices that reflected valuing humanizing mathematics, including conveying themselves as relatable to their students and presenting mathematics as a human endeavor. Kayla recollected her own experience as a student, and how she valued "professors who are more personal and kind

of come in and tell you about themselves," rather than "all I know about you is you do math." In particular, she mentioned while the students were in groups, how she "like[s] trying to sit with [the students] at the table … so I come off more relatable to them." Kendall similarly valued relatability in her classroom. She noted that just being a graduate student, "especially as a TA… [the students] feel more comfortable with us." When thinking about her overall approach towards teaching, Kendall revealed she "take[s] an approach that [she] is the student, like trying to be in their shoes."

This also transitioned into how Kendall thought about human aspects of mathematical learning, saying how "putting [herself] in [the students'] shoes, remembering how hard it was to grasp concepts can be super helpful to students." She acknowledged that mathematical learning is difficult and planned her teaching to reflect this. Similarly, Kayla recognized mathematics as a human endeavor by valuing mistakes in the learning process, saying "owning up to your mistakes [as the instructor], if you're wrong, it's fine. It's actually pretty encouraging for students to see when you do make a mistake, to be able to take accountability for it." Morgan also discussed the value of practicing mathematics and learning through mistakes, while also emphasizing there is a point in which as the instructor, "even if you make a plus or minus mistake, and if you do that every class, then that can, even it it's not about the concepts, that can hurt the students." Thus, the participants recognized a balance, whereby mistakes are integral and inevitable in learning and teaching mathematics, but there is merit in preparing for each lesson to minimize small mistakes. Morgan and Kayla also positively spoke about connecting mathematics to areas beyond the classroom. Kayla valued this as a student, saying that she really appreciated when professors "[gave] expert exposition to what they're doing" that connected the mathematical concepts to a real-world application or previously learned mathematical concepts. In her teaching, Morgan "tries to incorporate some applied things" to make the students feel more connected to mathematics.

Compassion and Care for Student Wellbeing

Each participant also emphasized valuing students' emotional wellbeing and embraced their role as supportive and compassionate instructors. When characterizing successful undergraduate mathematics instructors, Kayla conveyed that "having compassion for students, just as people, is a pretty big one." Similarly, Kendall shared that "our role [as instructors] is to guide [the students] along in more of an emotional sense and a math sense." Morgan specified that this could look like "someone who's very available for their students, who, you know, you feel comfortable going to their office horse, and they are very supportive… and really encourage students even if they're not the best students in the class." Thus, we see how each participant valued aspects of compassion and support for students in teaching mathematics.

For Morgan and Kendall especially, this valuing of compassion frequently arose in direct challenge to traditional mathematical discourses that legitimize innate mathematical ability over hard work and effort (Jaremus et al., 2020; Mendick, 2006). They recognized widespread stereotypes that position people as unintelligent if they perform poorly in mathematics or need additional supports (Leyva et al., 2021; Reinholz et al., 2019). Morgan talked about

how important it was to support those struggling in her course, referencing professors she had who were "not supportive enough" and "who teach to the top 1% of their class." She shared how she saw how "a lot of people have that issue with math where they're like, 'Oh, I'm too dumb to be in math' and that's just not the case… like, there's too many people telling people that they're not good in math." Kendall similarly exemplified valuing compassion, noting how "part of [her] approach is also being forgiving in a sense." She discussed how "a lot of students get disheartened" when they fail tests, and "part of our job as an instructor… is to be there when they need a mentor and then to remind them that they can still get this stuff." Both Morgan and Kendall's reflections highlighted their belief that students can learn mathematics through hard work and their role as supportive and compassionate instructors towards students in this learning.

Critical Experiences: Sites of Values Negotiation During Postsecondary Education

In conjunction with identifying and describing participants' values, we turned towards a narrative inquiry approach to make sense of how the participants navigated areas of postsecondary education where values about mathematics teaching and learning may have been shaped, reinforced, or questioned – which we refer to as *sites of values negotiation*. Graduate students engage in this complex process of values negotiation in numerous ways. Through linking participants' values of mathematics teaching and learning to reflections of their lived experiences in graduate school, the narrative inquiry approach suggested two notable negotiation processes: *affirming* and *countering*. Building on existing literature on values (mis)alignment in mathematics teaching and learning and the ways teachers, pre-service teachers, and students negotiate and co-construct mathematical values (e.g., Altan & Lane, 2018; Seah & Anderrson, 2015; Street, 2024), we conceptualize *affirming* to refer to the process by which participants aligned with or reinforced values they encountered in these sites. Conversely, countering refers to the process by which participants opposed or negated values they encountered in these sites. Given the variability of institutionalized pedagogical development in mathematics doctoral programs (Friedberg, 2005), understanding how graduate students develop and negotiate these values is critical. This is especially important for supporting the professional growth of women-identifying graduate students and giving space to how their perspectives align or conflict with dominant masculine values in the discipline. The following sites of values negotiation emerged in Kayla's, Morgan's, and Kendall's narratives: (1) interactions with faculty and advisors, (2) prior teaching experiences, (3) classroom experiences as students, and (4) the cohort experience in graduate school.

Interactions with Faculty and Advisors:

Participants described both alignment and tension with faculty and advisors' values. These tensions often led them to embrace opposing, often less dominant, perspectives—such as prioritizing compassion, care for students, and humanizing mathematics. As a site of values negotiation, one-on-one interactions during office hours were particularly influential. On the one hand, Kayla, Morgan, and Kendall encountered values they sought to emulate. For example, Kendall recalled the positive experiences she had with a professor during office hours saying, "He was not the type of person to look at you and be like, 'No, you're wrong.' He would not do that…I never felt stupid in his office, and I think that was really important to me." Experiencing this support was impactful for Kendall, suggesting

an affirmation of her value of demonstrating care and compassion for students, particularly through encouragement during moments of struggle with the mathematics content.

Kayla recalled a meaningful interaction with a woman-identifying faculty member where they discussed balancing roles as a wife, mother, and mathematics professor. This experience humanized mathematics for her, reflecting her commitment to being personable and relatable in her own teaching. Similarly, Morgan described the impactful relationship with her PhD advisor, illustrating how the student-advisor relationship unique to doctoral programs may influence graduate students' values related to mathematics teaching and learning. She recalled how her advisor responded to her experience with a qualifying exam: "He was like, 'You seem really sad that you got, about your score, but you should be happy you master's passed. That's great!'…He was just really, really kind." During this challenging time, Morgan remembered how "everyone else I had talked to was like, 'Oh, you didn't pass,'" but her advisor reminded her of her successes, combating pervasive narratives about women's mathematical abilities.

On the other hand, there were also faculty interactions in office hours when participants encountered the more oppressive, dominant values historically characteristic of mathematics education. For example, Kayla described an interaction with a professor:

> But it was just like, now it's dreading going office hours. And it's just like, that should not be the case. I should be like, "Okay, I'm going to office hours, I want to learn and I want to get help." It just felt like, I always had to walk on eggshells with what I asked him because if I asked him something, and he didn't want to answer it, he was like, "Well, that's like asking for the homework to get graded before it's graded." So he doesn't want to help me on the homework.

This reflection exemplified a values tension and moment of countering in Kayla's narrative as she faced a lack of support and discouragement to ask questions, reifying her values of demonstrating care and compassion for students in opposition to her experience. She said, "I think it's important to be a good person too and in addition to teaching math," and we found that she prioritized students' comfort asking questions and treating them with care and kindness. Across all participants, we observed that relationships and interactions with faculty and advisors were common sites where they confronted alignment and misalignment in values related to teaching and learning mathematics.

Prior Teaching and Mentoring Experiences:

Through roles as TAs, instructors of record, and research mentors, Kayla, Kendall, and Morgan engaged with pedagogical practices, student learning, and relational aspects of teaching. Their experiences reinforced their commitment to student-centered and collaborative values and also highlighted tensions between the values that prioritize performance, competition, and individual achievement. For all participants, experiencing agency as an instructor of record and being able to connect with students from that role was especially memorable. Kendall

commented, "...being able to teach my own course and explain my own course, have my own students, to everything the way I want it to be done and not have to take orders. That was great teaching-wise." She further emphasized that "the most enjoyable thing was probably the students. I had a really great group of students." These connections with her students align with her values of compassion, care, and humanizing mathematics

In addition, as participants enacted teaching practices reflective of their values, the positive impact affirmed their convictions about teaching and learning. For example, incorporating group work reinforced their commitment to collaboration as students engaged more actively with mathematics. In response to her positive experiences with group work, Kendall expressed how "I do think math classes need more group work, because I think it's super important for people to explain how they think about something and compare that to how other people think about it."

Lastly, prior experiences as research mentors highlighted the relational and interactive nature of teaching and learning. Through opportunities such as mentoring undergraduate students in Directed Reading Programs (DRPs) and Research Experiences for Undergraduates (REUs), the participants expressed fulfillment in guiding students through mathematical research. These experiences affirmed their appreciation for collaborative research environments, where mentorship is not just about mathematics content but involves fostering curiosity and sharing insights. To describe her experience as a DRP mentor, Morgan said, "I feel like that kind of makes me feel like, 'Oh, I'd really want this collaborative research environment or to be an advisor someday.'" Kendall similarly shared how much she enjoyed being a mentor to undergraduate students and collaborating on research projects with them throughout the year. Through these mentorship experiences, Morgan and Kendall encountered and exercised values such as collaboration and demonstrating care and compassion for students.

Experiences as an Undergraduate and Graduate Student:

Experiences as undergraduate and graduate students served as another important site of values negotiation. Kendall and Morgan spoke about this explicitly, with Kendall saying how she "want(s) to be pretty much exactly like a couple of professors that I had" and Morgan expressing how learning to teach for her was "just mimicking my favorite instructors a little bit until I kind of figured out what works for me."

Prior experiences as students often acted as frames around their teaching values of humanizing mathematics, caring for student well-being, and student-instructor perceptions. In terms of valuing mathematics as a human endeavor, Kayla discussed how "on the first day [of teaching], I just kind of like spill all about me as a person," because "the [professors]... that I know more about as a human being, are the ones that I've learned the best from." Kendall reflected about how her best professors were "willing to involve [their] students as much as possible, who take the time to get to know the students." One of Morgan's responses showcased how her valuing of mistakes in the learning process contrasted with an experience with professors who "only teach to the top 1% of their class… and I think that it makes students feel dumb." In these reflections, we saw how positive experiences with open and

personable professors affirmed Kendall and Kayla's humanizing values related to teaching, while Morgan's values countered her experiences with professors who portrayed exclusionary teaching philosophies.

The participants also relayed multiple negative experiences where they perceived a lack of instructor care. Given the way each participant emphasized valuing care and support for their own students, these negative experiences may have acted as jarring counterexamples in their developing teaching philosophies. Kendall expressed how "those professors are the best… the ones who you can genuinely tell that they care," however as a graduate student, she felt "a lack of support in that time… having trouble getting faculty to help study for [qualifying exams]." Kayla similarly expressed when she was having a difficult time with graduate coursework that she felt her professors "don't have a gauge of like [the workload],... I have to perform at this super high level, and it's like, you're dying the whole quarter." And when seeking help, Kayla shared how "[my professor] didn't want to help me on the homework… he was just upset that my understanding of it… wasn't at his level… I just felt awful about myself." Morgan similarly described difficulties with coursework, however acknowledging that "I think like, not every professor, but you can probably find a professor who always kind of understands the difficulty of being a grad student." Across the participants, coursework and qualifying exams were a major, often negative, experience and exhibited ways in which they did or did not experience instructor care during that time. These sites strongly opposed the ways in which the participants value caring for their own students.

Lastly, the participants' experiences as students may have also increased their awareness of the ways students perceive their instructors. Kayla recognized how she wants to

> break the stereotype of like, "Oh, you have to … be super scared of your professors…" Because I've had that where I've had professors get upset because you don't know something, and I'm like, yeah, no I'm not going to be that kind of person."

Morgan recalled how the way she perceived her advanced mathematics professors inspired her teaching path, saying "I really fell in love with the advanced math courses, and I really looked up to my math professor, and it was something that I was like, I'd love to be able to teach [advanced math] for a long time." In both these instances, the participants' perceptions of their professors reflected their own values around instructor-student perceptions as TAs.

Cohort Experiences:

The graduate cohort experience also arose as a site of values negotiation for our participants. In particular, the cohort experience bolstered valuing collaboration for both learning and emotional support. Kayla discussed this directly, saying how one of the most important aspects of her graduate career was:

> my cohort, or being able to do math with other people because that's when I feel like you learn the most math… I think that just goes with my math philosophy or my teaching philosophy… no matter how much in class they tell you to do things by yourself, it's like math is totally a community subject.

Learning mathematics with her cohort helped affirmed her values around collaboration for mathematical learning. Kendall discussed how her experience with qualifying exams produced a negative connotation with competition. She reflected how "that competition comes out in a negative way with those exams" and suggested ways in which her department could mitigate the competitive aspect, challenging sociohistorical mathematics discourses that value competition over collaboration.

Kayla and Kendall also described cohort experiences that aligned with their values around collaboration as a way to build interpersonal relationships in mathematics. Kayla talked about how having a close cohort was instrumental in getting through a difficult year in graduate school, saying how a positive aspect from the year was "the cohort that I'm a part of. I was able to make really good friends in it and stuff, and they're really supportive." Kendall also expressed how her cohort "support(s) one another. I think that's mostly where I get [support]... Just being there for each other." While Kendall and Kayla also discussed working on mathematics problems collaboratively, their narratives reflected connections between the emotional support they valued about their cohort and the way they valued collaboration in mathematics teaching.

Lastly, Morgan discussed her cohort experience similarly to how she expressed valuing asking for help and making mistakes as a humanizing approach to mathematics learning. Referencing her cohort, she mentioned:

> Having a really great relationship with my peers… like, if I don't give a perfect talk, or… I don't fully understand, people are very supportive… I can just talk to a lot of the grad students here, being like, "Oh, I have a question on this thing. Can you help me?"

Morgan's experience with her supportive peers mirrors the ways she valued students' questions and mistakes in the learning process as an instructor. Thus, we see across the participants how the cohort experience reinforced and may have helped shape their teaching values around collaboration and humanizing mathematics.

Discussion

The findings above detailed four values of teaching and learning mathematics held by three women-identifying graduate students. While these do not encompass all values held by women-identifying graduate students, the ways in which similarities in values emerged across these participants suggest challenges to the sociohistorical dominant masculine values in mathematics. We note tensions within the traditional Western feminine/masculine dichotomies of collaboration/competition, collectivism/individualism, emotional/logical, and hard work/innate ability. Mendick (2006) posits that mathematical values emerged from these dichotomies, firmly aligning mathematics with dominant

masculine values. However, the four values above position mathematics along the more feminine side of these dichotomies.

While mathematical environments often reflect the masculine value of competition (Hottinger, 2016; Mendick, 2006; Reinholz et al., 2019), the participants valued collaborative aspects for mathematical learning and interpersonal relationships. Collaboration alongside humanizing mathematics and demonstrating compassion suggests the importance of instructor-student and student-student relationships, echoing a collectivist view of mathematics rather than the traditionally masculine individualistic view (Lane et al., 2019; Mendick et al., 2008). The valuing of compassion and concern for students' wellbeing coincides well with values related to emotional aspects of learning mathematics. While dominant masculine discourses pose mathematics as purely logical and emotionless (Mendick, 2006), the participants acknowledged the ways mathematics can be difficult and laden with emotions such as frustration and loneliness. In response, they valued their role as understanding and compassionate instructors. Lastly, the participants also valued students' effort in their courses and the ways in which they could support students' perseverance in mathematics, countering perceptions that mathematical ability is innate and challenging stereotypical hierarchies that position men as more innately mathematically able (Hottinger, 2016; Reinholz et al., 2019). These examples demonstrate ways in which these women-identifying graduate students' hold teaching values that conflict and challenge traditional masculine mathematics values.

Lastly, by analyzing sites of values negotiations in postsecondary mathematics education, we found that participants encountered values alignment and misalignment through interactions with faculty and advisors, prior experiences as students, prior teaching and mentoring experiences, and their cohort experiences (Gardner & Holley, 2011). Prior scholars have theorized and illustrated how women-identifying graduate students' professional socialization to faculty roles shape their beliefs and commitments (Austin & McDaniels, 2006; Herzig, 2004; MacLachlan, 2006). We extend this work by illustrating nuances in women-identifying graduate students' values and the ways in which aspects of their professional socialization act as sites of values negotiations during graduate education, including participants' processes of affirming and countering values they experienced in these sites. While these processes align with existing scholarship on teachers' and students' values, identity development, and critical reflection (e.g., Seah & Anderrson, 2015; Street, 2024), our work sought to foreground the specific experiences and contexts of graduate education as key sites of values negotiation. We highlighted how some relational and institutional dimensions of postsecondary education shaped how Kayla, Morgan, and Kendall came to recognize, uphold, or resist certain values, offering new insight into the professional identity developmental trajectories of prospective faculty.

We observed Kayla, Morgan, and Kendall encountering values in sites that are not explicitly centered around mathematics instruction, but these experiences intertwined with their values related to mathematics teaching and learning. This demonstrates the breadth and depth of aspects of postsecondary education that have the capacity to influence graduate students' values. For example, interacting with their research advisors reinforced values about

compassion and care, and navigating the doctoral program as a cohort exemplified the positive impacts of collaboration and humanizing mathematics. While these types of experiences (e.g., experiences as students, relationships with advisors, etc.) have been recognized as significant moments of socialization, we identified how these experiences served as sites for graduate students to encounter and negotiate values related to teaching and learning mathematics.

Implications and Future Work

The values highlighted above resonate with existing characterizations of pedagogical practices that advance equity in undergraduate classrooms (e.g., Pai et al., 2024; Rubel, 2017). For example, participants' values point to the notion that mathematics teaching is an interpersonal, social activity that builds connections between people. Moreover, their values and reported practices echo some of our contemporary understanding of the experiences of women-identifying faculty in STEM, such as reporting using more student-centered pedagogies than their men-identifying counterparts (McMinn et al., 2022). We found that Kayla, Morgan, and Kendall held values that may be conducive to developing their understanding and expertise of equity-based practices. We conjecture that values alignment and misalignment can influence how graduate students come to learn about and take up these practices. Research has shown that integrating equity-based pedagogies into a teacher's regular practice can be a slow process (e.g., Shadle et al., 2017; Walter et al., 2021), however, future work can more closely examine how graduate students' values align with the values that underpin equity-based practices and how to leverage these values to better support their pedagogical development.

This work further implicates departments and institutions to reflect on the values explicitly and implicitly promoted in their mathematics programs and how to better affirm and legitimize women-identifying graduate students' values related to teaching and learning mathematics. Women remain underrepresented at the faculty level, with women making up just 27% of professors at the assistant, associate, and full professor levels (NSF, 2021). Furthermore, across all disciplines, tenure-track women faculty are more likely to leave and less likely to be promoted than men at every career stage (Spoon et al., 2023). Women in STEM frequently cite the department climate as a major factor in their decision to leave their faculty position, expressing feelings of exclusion and "lack of fit" (Casad et al., 2021; Spoon et al., 2023). Thus, the different sites of values negotiation we discussed pose critical implications for departments and institutions in creating spaces that support and celebrate a diverse set of mathematics education values.

Our findings reflect work that suggests "women and students of color sometimes bring new values to graduate programs, and since dominant values and roles are most typically valued by universities, these students are often urged by advisors to divest themselves of characteristics that differ from the mainstream (Austin & McDaniels, 2006, p. 406). Although we considered factors beyond advisors, numerous sites of values tension arose for our participants, insinuating that their values related to teaching and learning mathematics were not mainstream nor accepted. The sites we outlined largely represented informal spaces where graduate students negotiated their values

within the formal academic environment. However, departments could formalize these sites to support women-identifying graduate students' values, such as by creating opportunities for graduate students to connect with each other and faculty, supporting ways for graduate students to take on instructor or mentoring roles with undergraduate students, or providing resources or training opportunities for graduate-level instructors to diversify their teaching practices. Cultivating opportunities for graduate students to articulate, make sense of, and share their values related to teaching and learning mathematics can equip graduate students, mathematics departments, and institutions with new insights and framing on how to create a more inclusive mathematics environment and better support graduate students' pedagogical development and transition to faculty positions.

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