Exploring Women-Identifying Graduate Students' Values Related to Teaching and Learning Mathematics

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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.

Keywords: Graduate Teaching Assistants (GTAs), gender, values, equity

The values that women-identifying mathematics graduate students hold about teaching, student learning, and pedagogy 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 will 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 (National Science Foundation, 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 are often in contrast to the more traditional, 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 essential not only for supporting the professional development of women-identifying graduate students but also for illuminating how their values align or misalign with the longstanding norms and discourses of the mathematics discipline (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 has shown that when there is a mismatch between personal values and the prevailing culture of the discipline, individuals may experience role conflict, reduced job satisfaction, and a heightened likelihood of leaving the profession (Gardner & Holley, 2011). Conversely, when institutions recognize and support diverse values, it can lead to more inclusive teaching practices, innovative pedagogical approaches, and a more welcoming environment for both students and faculty (Casad et al., 2019). Therefore, examining the values of women-identifying mathematics graduate students provides critical insights into

how these emerging educators may challenge or reinforce existing pedagogical norms and helps to identify potential areas of misalignment that could be addressed to promote greater inclusivity within the discipline. In this preliminary work, we seek to illustrate values that women-identifying graduate students hold related to student learning and teaching. In particular, we asked: What do women-identifying mathematics graduate students value about mathematics teaching and learning? In what ways, if any, do their values align with or challenge dominant values in postsecondary mathematics education?

Conceptual Framing

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 value tension for those unable or unwilling to assimilate into the masculine culture of mathematics (Levya, 2017; Mendick, 2006). This tension can force women in mathematics to either conform or sacrifice components of their gender identity to be a mathematician (Hottinger, 2016). While a growing body of work relates to how marginalized students' values contrast with and challenge the dominant masculine values in undergraduate mathematics (e.g., Fong et al., 2019; Levya, 2021; Street, 2024), limited, if any, examine graduate students' and instructors' values related to teaching and learning mathematics.

Seah et al. (2016) operationally defined 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 activities that focus on consolidating materials 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. We focus the present work on women-identifying graduate students' values to highlight their perspectives in a masculine domain and connect to emerging work challenging exclusionary gendered mathematical discourses.

Methods

Context and Participants

This study was conducted at a large, research-intensive 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 requested their participation in a 90-minute interview. A total of six students participated in the interview, but in the present work, we focus on the three women-identifying graduate students from the sample (See Table 1; all demographic information was self-selected or self-described). At this department, serving as a teaching assistant (TA) involved planning for and facilitating sections (i.e., recitation hours). All participants had experiences as TAs and as instructors of record for lower division mathematics courses. Each of the three participants researched theoretical mathematics (Kayla was interested in geometric group theory, Kendall was focused on lower dimensional topology, and Morgan was researching quantum algebra and knot theory) and all expressed intentions to continue their careers as faculty members in a mathematics department at a postsecondary institution.

Table 1. Participant information

Name	Race and/or Ethnicity	Year in Ph.D. Program	Other self-described identities
Kayla	White/Caucasian	1st	Underrepresented student, Christian
Kendall	White/Caucasian	5th	
Morgan	White/Caucasian	5th	Underrepresented student

Aligning our work with transformative feminist theories and approaches (e.g., Creswell & Plano Clark, 2011; Du Bois, 1983; Kitzinger & Wilkinson, 1997, etc.) 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. Centering women's experiences in mathematics and illuminating the values they hold is important in its own right. With a special focus on their gender identities, we aim to contribute to and expand the field's understanding of mathematics graduate education by describing some of the values that women-identifying graduate students hold regarding teaching, student learning, and pedagogy. However, it should be noted that our analytical focus on Kayla's, Morgan's, and Kendall's values is not intended to homogenize nor generalize to women-identifying graduate students in mathematics doctoral programs.

Data Collection and Analysis

We utilized Zoom to conduct one-hour semi-structured interviews (Rubin & Rubin, 2011) focused on students' experiences in graduate school, including the supports and barriers they encountered, their perceptions of the mathematics professoriate, and their understanding of mathematics teaching. We analyzed the interview transcripts using Saldaña's (2013) method of pre-coding, first-cycle, and second-cycle coding. We engaged in pre-coding by first independently reading through each transcript and identifying instances that participants articulated values related to mathematics teaching, student learning, etc. Our 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 included discussing how the codes represented themes related to 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. For the present study, we highlight four themes related to participants' values about teaching and learning mathematics: *Collaboration*, *Student-Instructor Perceptions*, *Humanizing Mathematics*, and *Compassion and Care for Student Wellbeing*.

Results

Given the limited scholarship on mathematics graduate students' values about teaching and learning mathematics, we utilize a descriptive approach to illustrate these women-identifying graduate students' values. It is important to note that the following values are not mutually exclusive, and we observed participants expressing values that encompassed multiple themes.

Collaboration

Kendall, Morgan, and Kayla all valued collaboration in mathematics and reported implementing instructional practices that encouraged students to engage with one another, converse with peers, and make sense of the mathematics together. Although some of their efforts to foster collaborations were similar (e.g., group work during sections), the underpinnings of why they valued collaboration in mathematics classrooms differed. Kendall and Morgan understood collaborative sensemaking and interactions with others during class as aspects of instruction that advance students' learning of the mathematics content. They considered group work to be most beneficial because it affords opportunities for students to explain their thinking to others and teach their peers. To explain why she utilized group work in her teaching, 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 is an aspect of mathematics instruction that supports students' learning.

Alternatively, Kayla valued collaboration in mathematics because it encouraged interpersonal relationships among the students and allowed her to foster connections with students. For example, she acknowledged while doing mathematics homework that, "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, Kayla did implement collaborative activities in the classroom, emphasizing how those activities helped bolster connections with her students. She reflected, "I usually would just say like, 'Alright, break up into groups of two and three. 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.'" Thus, Kayla valued group work as a means to immerse herself with students and better connect with them.

Student-Instructor Perceptions

A notable value that participants held around mathematics teaching and learning centered around how the members of the learning community viewed each other. They acknowledged the impact of students' perceptions of them, and conversely their perceptions of students, on the broader dynamics of the classroom. Morgan shared,

> 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, to know where they're at in the class and things like that. I think those professors are the best, and the ones who you can genuinely tell that they care. That's the truth.

She valued the student perception that professors and instructors genuinely care about their students. Additionally, participants described other pedagogical practices that would result in positive portrayals of themselves to students. For example, Kayla explained, "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 made sense of how students perceived TAs and instructors and understood preparedness and organization in the classroom to be related to levels of respect. Similarly, Morgan valued providing clarity in the classroom expectations. She said, "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." Again, the notion of being clear and organized emerged and suggests that these graduate students are actively making sense of how students perceive them as TAs and instructors in the classroom.

Interestingly, we also found evidence of participants valuing 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 on these students, 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 and valued the students' efforts and motivation, and this made connecting with them easier and more enjoyable for her. Overall, we found that participants' value of connecting with students was deeply intertwined with their values of humanizing mathematics and exhibiting compassion. We unpack these in more detail below and recognize that participants considered these practices to collectively foster positive connections with students.

Humanizing Mathematics

Kendall, Morgan, and Kayla all discussed pedagogical components that reflect valuing humanizing mathematics, including presenting 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 the 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 value 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 their role as supportive and compassionate instructors. When asked about what characteristics make a successful undergraduate mathematics instructor, Kayla responded 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 value innate mathematical ability over hard work and effort (Jaremus et al., 2020; Mendick, 2006). In their interviews, they recognized the prevailing mathematical discourses that paint the discipline as extremely difficult with little support and widespread stereotypes that position people as unintelligent if they perform poorly in mathematics (Leyva et al., 2021; Reinholz et al., 2019). Morgan talked about how important it was to her to be a supportive instructor to those struggling in the 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 portrayed her valuing of 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 interviews highlight their belief that mathematical knowledge can be learned through hard work as opposed to a solely innate skill, and they valued their role as supportive and compassionate instructors towards students in this learning.

Discussion and Conclusion

The findings above detailed four values of teaching and learning mathematics held by women-identifying graduate students. While these do not encompass all mathematics education 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. In particular, we see 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 the values of humanizing mathematics and compassion suggest the importance of instructor-student and student-student relationships, reflecting 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 coincide 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 or loneliness and valued their role as understanding and compassionate instructors. Lastly, the participants also valued students' effort in their courses and the ways in which, as the instructor or TA, 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 values that conflict and challenge traditional masculine mathematics values as mathematics instructors.

Implications and Future Work

Morgan's, Kendall's, and Kayla's values highlighted in this work resonate with and reflect existing characterizations of pedagogical practices that advance equity in undergraduate classrooms (e.g., Pai et al., 2024; Rubel, 2017). For example, their values point to the notion that mathematics teaching is an interpersonal, social activity that builds connections between people. Additionally, their values and reported practices echo our contemporary understanding of the experiences of women-identifying faculty in STEM. For example, they are seen as caregivers and feel pressure to be perceived as nice and nurturing (Guarino & Borden, 2017; Hart, 2016). Women faculty also report being more student-centered in their pedagogies than their male counterparts (McMinn et al., 2022). Future work will more closely examine how graduate students' values align with the values that underpin equity-based practices, which may potentially misalign with historically dominant values in mathematics education. We conjecture that values alignment and misalignment can influence how graduate students come to learn about and take up these practices, and this can have significant implications for how mathematics graduate programs prepare students for careers as faculty. 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), and we suggest that examining and leveraging graduate students' values is one way we can better support their pedagogical development. Our findings revealed that these women-identifying graduate students hold values that may be conducive to developing their understanding and expertise of equity-based practices. Providing opportunities to articulate and make sense of one's values related to teaching and learning mathematics can equip graduate students, mathematics departments, and institutions with new insights and framing on how to better support their pedagogical development and transition to faculty positions.

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