

Exploring the Connection Between Women of Color's Values and Mathematical Identity in Undergraduate Mathematics

Ciera Street
Colorado State University

The growing call for more equitable and just mathematics classrooms includes supporting and strengthening students' mathematical identity. Recent scholarship proposes a connection between students' mathematical identities and their values (Kalogeropoulos & Clarkson, 2019). However, limited research acknowledges and explores mathematics identity at the intersection of gender and race (Leyva, 2021; McGee, 2016). Furthermore, undergraduate mathematics in the United States often does not reflect the cultural values of women or students of color (Fong et al., 2019; Leyva, 2016, 2021). Informed by sociopolitical theory and an intersection lens, this study explores women of color's mathematics education values and the connections between those values and their mathematical identity. Through interviews and mathematical autobiographies, participant examples indicate various values, including those related to learning from mistakes and social support. Preliminary results suggest that the presence of these values in mathematics environments may support women of color's mathematical identity.

Keywords: Equity, Mathematical Identity, Values, Gender, Race

In the growing call from research and professional organizations within mathematics education to create more equitable and just mathematics classrooms (e.g., Mathematical Association of Mathematics Instructional Practices Guide, 2018; National Council of Teachers of Mathematics, 2014), one area of interest focuses on supporting and strengthening students' mathematical identities. Mathematical identity encapsulates students' relationship with mathematics and their perceptions of themselves as a doer of mathematics, including their beliefs about ability and participation, sense of belonging, and institutional and interpersonal supports (Voigt, 2020). Research suggests that gendered and racialized mathematical discourses play an important role in students' development of their mathematical identity, however, limited scholarship exists that acknowledges and explores mathematics identity at the intersection of gender and race (Leyva, 2016, 2021; McGee, 2016).

Recent scholarship proposes a connection between identity and values, such as mathematics teachers' professional identities and their values and students' mathematical identities and their values (Kalogeropoulos & Clarkson, 2019; Mandt & Afdal, 2022). There is general consensus that values are sociocultural in nature, embodying cultural norms about what is bad or good, or worth avoiding or doing (Hill et al., 2021; Schwartz et al., 2011). Thus, values in mathematics education includes one's belief about what is important and worth doing in mathematics, as well as what drives one course of action over another (Hill et al., 2021; Seah, 2019). Given that "what we value reflect years of learning and influence from our historical experiences and social interactions as members of the culture we belong," (Seah, 2018, p. 564) I argue that the relationship between identity and values in mathematics must be similarly influenced by gendered and racialized mathematical discourses. To this point, undergraduate mathematics in the United States often does not reflect the cultural values of women or students of color (Abrams et al., 2013; Fong et al., 2019; Leyva, 2016, 2021). Various scholars recognize how mathematical discourses in the US often align with, and thus give power to, dominant masculine and white values such as competition, risk, and individualism (Bullock, 2019; Jaremus et al.,

2020; Leyva, 2016, 2021; Martin, 2006). Thus, unique and possibly additional tensions within mathematical spaces emerge at the intersection of race and gender for women of color as they develop their mathematical identity while negotiating their values with dominant mathematics values (Carlone & Johnson, 2007; Leyva, 2017; Rodd & Bartholomew, 2006). Supporting and incorporating women of color's cultural values within undergraduate mathematics may help reduce these tensions and better support women of color's mathematical identity development (Battey & Leyva, 2016; Hunter, 2021; Seah et al., 2016). Thus, this research engages critical frameworks at the intersections of gender and race to challenge exclusionary adherence to dominant values and encourage counternarratives to white, masculine mathematical discourses. In this research I ask, (1) What do women of color STEM majors describe as valuable/important to their undergraduate mathematics education? And (2) In what ways, if any, are these valued/important components connected to their mathematical identity?

Theoretical Perspective

I utilize sociopolitical theory and an intersectional lens to inform this work (Adiredja & Andrews-Larson, 2017; Crenshaw, 1991). This decision stems from the sensitivity of mathematics educational values to both the culture of the learner and societal influences (Hunter, 2021; Lee & Seah, 2015; Zhang, 2019). Given the white, patriarchal discourses within undergraduate mathematics, an intersectional lens helps describe the ways in which interactions between race, gender, class, and other social constructs account for overlapping discrimination imposed on people with multiple marginalized identities within societal systems (Crenshaw, 1991). Within the cultural system of mathematics, we recognize that the values women of color hold are both individually unique as well as shaped by societal influences related to gender and race. In particular, sociopolitical theory emphasizes the ways in which knowledge, power, and identity emerge and are often constrained by the values and norms of the mathematics environment. This theory challenges the currently "accepted" values and norms within the culture of mathematics, which often inequitably affect students' perceptions of themselves as doers of mathematics (Adiredja & Andrews-Larson, 2017). Sociopolitical theory rejects student assimilation into the current dominant culture and instead promotes a system that considers, supports, and affords space to various backgrounds and identities. Thus, I chose to center women of color in this analysis to provide counternarratives to the white, patriarchal mathematical context without comparisons to the dominant group. Instead, I highlight the often submerged and undervalued variety of experiences of women of color related to mathematical identity and values.

Methods

Data Context and Participants

The data for this study include transcripts of follow-up interviews and mathematics autobiographies from participants who completed the *S-PIPS-M* survey instrument administered by the Progress through Calculus (PtC) project in 2017-2018. This survey collected information about undergraduate students' experiences in precalculus and calculus, including mathematical activities, interactions, and affect (Street et al., 2021). To recruit participants for this study, I sent out an interest survey in Spring 2022 to all women of color from the survey who consented to future contact ($n = 1121$). Women of color within this dataset includes any participant who selected at least woman from the following select-all response options related to gender: Man, Transgender, Woman, Not listed (please specify) and who selected at least one of the following

select-all response options related to race and/or ethnicity: Alaskan Native or Native American, Black or African American, Central Asian, Hispanic or Latinx, Middle Eastern or North African, Native Hawaiian or Pacific Islander, Southeast Asian, South Asian. The recruitment email described the study as an exploration of women of color STEM majors' experiences in undergraduate mathematics and thus participants self-selected as a woman of color to participate in this follow-up study. The interest survey included questions about demographics, various experiences and feelings related to undergraduate mathematics, and how those experiences and feelings related to race and/or gender, if at all.

Of those who responded to the interest survey, I selected participants based on results from a previous analysis as well as aiming to diversify the sample in terms of gender, race/ethnicity, university, and major. Previous analysis using this dataset grouped the full *S-PIPS-M* survey sample of women of color into clusters based on components of mathematics identity. Thus, I selected 12 participants to interview that span across these clusters while attending to the characteristics listed above. For this analysis, I focus on two participants, Lyka and Callie. Brief descriptions of Lyka and Callie are presented in Table 1. The participants self-described their gender and racial identities through an open-ended question on the interest survey.

Table 1. Description of participants.

Lyka	Callie
Lyka (she/her) is a Filipino and white cisgender woman. She recently graduated with degrees in Biomedical Engineering and Multidisciplinary Studies from a public university in the Eastern half of the United States. Within the mathematics department at her university, she completed College Algebra, Trigonometry, Calculus I, Calculus II, Multivariable Calculus, and Ordinary Differential Equations.	Callie (she/her) is a Hispanic/Latino cisgender woman. She recently graduated with a degree in Biology from a public university on the East coast. Within the mathematics department at her university, she completed College Algebra, Precalculus, Trigonometry, Statistics, and Calculus I.

Data Collection

In Spring 2022, I conducted 60 - 90 minute, semi-structured virtual interviews with each participant. The interview protocol included questions about participants' experiences and feelings related to undergraduate mathematics, including their perceptions of themselves as doers of math and what they found to be supportive and valuable in mathematics spaces. I divided the interview questions into four categories, three of which were informed by Voigt's definition of mathematical identity and one focused specifically on the potential connections to gender and/or race. This categorization intended to bring forth participants' narratives around their mathematical identity as well as components they felt were important and valuable in their mathematics education. I also asked participants to write a brief mathematics autobiography using an open-ended prompt. The prompt encouraged participants to highlight memorable and influential moments in their life related to mathematics up to and including college, along with any ways in which race and/or gender interacted with these moments. I asked participants to complete the mathematics autobiography prior to their interview.

Data Analysis

To analyze the transcripts, I used Saldaña's (2013) pre-coding, first cycle, and second cycle coding methods. Pre-coding occurred during the interviews and during the transcription process, whereby I noted particularly interesting or powerful statements. During the first cycle I utilized open coding to label any statements related to the research questions, including statements related to cultural values, mathematics education values, and the components of mathematical identity. These codes became the basis of the second cycle coding process which involved categorizing the initial codes into theoretical codes to help describe the overall story connecting the data to the research questions. The coding process is still in progress and thus the results section that follows includes preliminary findings and developing themes.

Results

Initial findings suggest mathematics education values associated with learning from mistakes, connecting to the real-world and future careers, clarity in mathematical explanations, and social relationships, such as with their instructor and peers. There also appears connections between these mathematics education values and their mathematical identity. Intertwined within these mathematics education values and connections to mathematical identity, I also note the role of cultural values, especially related to gender and race. I present here two examples, one from each participant, to exemplify some of these points. Future analysis will provide more detailed and potentially addition results and overarching themes.

Lyka's Example

In her mathematics autobiography, Lyka describes a stigma she perceives in STEM, where "if you mess up that's not only reflective of you as a person, but women as well, the same goes for race." However, she describes how much she valued and enjoyed her mastery-based upper-level calculus courses where she felt that having the opportunity to work through her mistakes made the process "less stressful and made me enjoy doing math. I was able to focus on the meaning of the content." She attributes those courses as the reason she decided to pursue a mathematics minor. This suggests that seeing her mathematics education values reflected in her math courses improved how she felt about math and herself as a doer of math. In Lyka's experience, we see how cultural values around making mistakes in mathematics, and how those interacted with being a woman of color in STEM, were challenged within her mastery-based math courses. When instead the value of making mistakes aligned with her values around learning and improvement, she added a mathematics minor, suggesting a strengthened mathematics identity.

Callie's Example

Callie describes both positive and negative experiences within undergraduate mathematics. She acknowledges how her performance often related to her feelings toward the courses. However, how she describes the importance of social support emerges across these experiences. When detailing her math courses, she recognizes that for most part "you were kinda on your own, and it was up to me... I was really good at forming friends within those classes so we could study together." The role of social support also influenced her perceptions of herself within mathematics and her major. When describing a fellowship she engaged in during college specifically geared toward marginalized students in STEM, she emphasizes how "that fellowship that I had is like a very big reason why I continued to do so well in all these [math] classes... I probably would have changed my major completely if I wasn't in this fellowship." She continues

to talk about how the importance of this social support intertwined with her gender and race, “because they did help me a lot with just like the reassurance of like, listen, this isn’t a common thing like, you’re a woman, you’re a minority.” Even though Callie describes overall having a negative feeling toward mathematics, having a space that reflected her values around social support and made her feel less alone as a woman of color in STEM provided a positive connection with mathematics and her major.

Discussion

The above preliminary results suggest various values women of color relate to their experiences in mathematics. These include social relationships, such as the importance of peer support and organizational support for Callie, learning from mistakes, such as Lyka described in her mastery-based math courses, connections to the real-world and future careers, and clarity in mathematical explanations. Additional values may emerge as I complete the analysis. There also appears to be a connection between these women of color’s values and their mathematical identity. In particular, they both mention the importance of a value-related component in their STEM degree considerations. Future analyses will explore this connection in more detail, including when and in what way values relate to students’ mathematical identity. These results also support the use of sociopolitical theory and an intersectional lens given the inclusion of statements regarding the influence of gender and race on their experiences. Once the findings and overall themes are established, I will more robustly consider in what ways these women of color’s values connect with previous literature about women and people of color’s values and mathematical identity and how these results intertwine with gender, race, and the tensions often present within dominant mathematical systems. The implications of this work aim to consider how women of color’s values emerge in mathematical spaces and the role of the university to incorporate those values to better support women of color in undergraduate mathematics.

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