

Underrepresented Students' Legitimization as Peripheral Participants in the Mathematics Research Community of Practice

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This paper presents preliminary findings on underrepresented students' experiences as they navigate the mathematics research community. Three undergraduate mathematics majors from underrepresented groups were interviewed regarding their experiences at their home institution, research experiences for undergraduates, and an undergraduate mathematics conference. Using communities of practice as a theoretical framework, we explore these students' status as legitimate peripheral participants in the mathematics research community of practice. Analysis led to bridging the communities of practice framework with Gutierrez's (2009) four dimension of equity. In this paper, we focus on the ways in which students' real or perceived legitimacy were impacted by identity and power. In particular, students experienced de-legitimization via the power of the dominant group and via less peripheral members.

Keywords: mathematics majors, community of practice, identity, equity

Mathematics majors engage with mathematics research in a variety of ways during their time as an undergraduate. These experiences go beyond the classroom and their work with their advisor at their home institution. Increasingly, STEM majors participate in activities such as research experiences for undergraduates (REUs) (National Academies of Sciences, Engineering, and Medicine, 2017) and conferences. These experiences are essential for students seeking entry into graduate school (National Academies of Sciences, Engineering, and Medicine, 2017; Peterson & Rubinstein, 2016; Russell et al., 2007). Activities such as REUs expose students to greater opportunities for research, faculty connections, and peer networking. Work examining the holistic experience of mathematics majors must take into account these critical aspects of their development as researchers.

In addition, little research exists on the experiences of underrepresented students as they navigate mathematics research, REUs, or conferences. Research on STEM undergraduates in REUs has shown increases in persistence and promotion of mathematics identity formation (National Academies of Sciences, Engineering, and Medicine, 2017). However, much of the work on the role of REUs in identity formation has not been specific to underrepresented students (Palmer et al., 2015; Seymore et al., 2004). Given importance of these activities for access to graduate school, equity work within the mathematics community must consider how underrepresented students experience not only their local home institution environment but also their holistic experience including activities such as REUs and conferences.

Using a community of practice lens, this work seeks to answer the research question: How do underrepresented mathematics majors describe their experiences in the mathematics research community?

Theoretical Framework

A community of practice is defined by Wenger (1998) as having three dimensions: a joint enterprise, mutual engagement, and shared practices. For example, the work of tailors is a community of practice (Lave & Wenger, 1991). In a community of practice, experienced members (experienced tailors) mentor newcomers (apprentices) to take-up the practices of the

community. These practices include ways of doing, knowledge, and language. To join the community, newcomers must be granted access through sponsorship by an old-timer. At this time, newcomers become legitimate peripheral participants in the community, having gained legitimacy through their sponsorship. The newcomers are participants in that they engage in the joint enterprise of the community, but their work is peripheral as they are given smaller, easier subcomponents of the work and have a great deal of oversight from a more experienced member. Overtime, newcomers are given more complex tasks and independence as they update the community's practices and become fuller members.

To better understand the experiences of underrepresented minorities as mathematics majors, we seek to bridge community of practice (Lave & Wenger, 1991) with Gutierrez's (2009) four dimensions of equity. Gutierrez outlines four dimensions of equity, lying on two axes. On the dominate axis are access and achievement and on the critical axis are identity and power. We view each of these four dimensions as tied to aspects of legitimate peripheral participation. Newcomers to a community of practice need access as granted by sponsorship by an experienced member, providing their legitimacy as a member of the community. As newcomers gain achievement, their participation becomes less peripheral as they moved towards full participation and membership. Further, as newcomers participate in the community, their identities shift based on how they perceive themselves and their participation in the community (White & Lowenthal, 2011). Finally, the full members in the community who hold power are those who are able to decide what it means to be a legitimate participant (Gutierrez, 2013). White and Lowenthal argue minority students must "adopt a form of discourse that originated in and often perpetuates oppression" (p.289) to participate in the community, as dictated by those in power.

In this work, we focus on the mathematics research community as a community of practice. Newcomers are students who are mathematics majors and experienced member are advisors and tenured faculty. Non-tenured faculty, graduate students, and more advanced peers are relative experienced members to mathematics majors. These members of the community of practice have greater legitimacy and fuller participation than the mathematics majors but less legitimacy and participation than tenured faculty. Students choose to enter the mathematics research community by declaring a mathematics major and are granted access, or legitimacy in the community, by their advisors. The ability to gain legitimacy and enter the community is connected to Gutierrez's (2012) dimension of access. Students are peripheral participants in the mathematics research community as they are given smaller tasks with close oversight by advisors. Achievement in these activities and coursework, as well as uptake of community practices are required to become a fuller participant in the community and to move away from the periphery. As students negotiate their place in the community, their identities will shift. Students will possibly experience tensions between their dynamic identities and as their perception of their role within the mathematics research community changes. Each student will experience the power relations within the mathematics research community differently. Some will find the privileged mathematic research community discourse to be similar to their everyday discourse. Others will need to learn a new discourse to "fit in". Among legitimate peripheral participants, power relations may be based on identity, institution, area of research, awards won, or any number of achievements, access, and identity markers.

Methods

Data for this study was collected during a conference for undergraduate mathematicians. At the end of the application process for the conference, students were asked to complete a demographic survey, a subset of questions from the X-PIPS-M survey (Apkarian et al., 2019). Of

the 59 students accepted in the undergraduate mathematics conference, 18 students completed the survey and consented to participate in the research. The results of the demographic survey were used to select students to interview, seeking women and/or underrepresented students. This work reports on three mathematics majors with intersectional identities as underrepresented students across multiple demographics. Pseudonyms are used to protect student identities. Amira self-identified as female, black or African American, middle eastern, and white. She was also a transfer student. Cuc self-identified as non-binary and southeast Asian. They were a first-generation college student and transfer student. Ethan identified as male and Hispanic or Latinx. He was an international student and first-generation college student. Interviews were conducted on the final day of the conference and the week after. Interviews were conducted as semi-structured with students being asked questions about their experience as a mathematics major at their home institution, their experience with research experiences for undergraduates (REUs), and the undergraduate mathematics conference. Questions were aimed to get a sense of factors influencing students' trajectories and how their identities contributed to their experiences. Interviews were then transcribed. Data analysis was conducted via thematic analysis (Braun & Clarke, 2006). Interview transcripts were read multiple times before inductively coding each talking turn to capture the essence of the turn. Codes were then compared to look for themes across the data. Themes continued to evolve as frameworks were applied to make sense of them.

Results and Discussion

Our results focus on the most encompassing theme which emerged from the data: Legitimacy as a Participant in the Mathematics Research Community of Practice. In our data, we found students' perceptions of their legitimacy to be heavily influenced by their interactions with peers. Specifically, students questioned their legitimacy based on their interactions with students in the dominant group and with students perceived as having greater achievement in the mathematics research community.

We connect students' real or perceived legitimacy within the mathematics research community to Gutierrez's (2012) critical axis of identity and power. We see power as held by members in the community who are able to grant or restrict legitimacy within the community. Students belonging to the dominant group within the mathematics research community have greater power over their nondominant peers. In addition, students with greater achievement have moved further into the community, becoming fuller participants, granting them increased legitimacy and power. Students' identities as legitimate members of the mathematics research community are determined in part by the individual and in part by others (Gutierrez, 2013). That is, their peers play a role in students' mathematics research community identity formation.

Delegitimization via the Power of the Dominant Group

Several students detailed negative experiences with peers either at their home institution, an REU, and/or the undergraduate mathematics conference. For some, these included microaggressions such as scoffing, interrupting or "mansplaining". Amira described feeling "on edge" before asking a question, nervous she would justify her peers' behaviors. Through their behaviors, peers indicated Amira didn't belong in the mathematics research community, that is, she was not a legitimate participant. Davies (2005) notes that it is not enough to participate in the community, but one must be accepted as well to become a full member. Amira was concerned that her mathematics questions or contributions in class would prevent her from being accepted into the community and confirm that she was not a legitimate participant.

For similar reasons, Ethan described that as a Hispanic first-generation college student, he had developed a “math personality”. Ethan described this personality as “very professional” and that he would talk with others in the community “about math...not so much on my background because there’s just not a lot of people from my background.” By describing his mathematics research community identity as professional, Ethan implied that his background was not professional and did not belong in the community. Ethan adopted an identity which he felt legitimized him as a participant in the mathematics research community. He focused on connecting with his peers through mathematics and their similar mathematics experiences, avoiding discussing his background. Similarly, Cuc felt the need to hide their use of she/they pronouns after a negative interaction with a few students whom they felt didn’t “have good allyship”. Ethan and Cuc felt the need to change or hide aspects of their identity in order to belong to and be a legitimate member of the mathematics research community. White and Lowenthal (2011) describe conflicts that occur when students’ individual culture differs from the academic discourse community, here, the mathematics research community. Ethan and Cuc both describe code switching to navigate between their individual culture or identity, and what was required to belong in the mathematics research community.

De-legitimization via Perceptions of Less Peripheral Members

Amira and Ethan both described feeling intimidated by their peers. Ethan felt some students were pretentious and tried to impress others which led him to feel the mathematics research community wasn’t for him. Peers used the discourse of the mathematics research community to come across as less peripheral members. This display of power resulted in Ethan feeling as though he didn’t belong in the community. However, Ethan also stated that over time, he knew more about mathematics and could tell when students were trying to sound impressive. As Ethan himself became a less peripheral member, he could identify these embellishments of power. At the same time, he was still cautious, not wanting to look dumb or confirm stereotypes. Similarly, Amira described feeling nervous around “celebrity” students whom she described as high achievers who are known across institutions, and who are prestigious based on who they work with and know. “I was very nervous because...I knew that there were like, very prestigious programs that like, sent their students [to the undergraduate mathematics conference] and very high-level students and I was sort of worried that like, for example, my presentation might pale in comparison”. Amira was concerned others would think her research wasn’t good enough, or legitimate. Both Ethan and Amira worried about their legitimacy in the mathematics research community in relation to peers they viewed as more legitimate and less peripheral, experiencing imposter syndrome (Murray et al., 2023). Murray and colleagues found those with imposter syndrome do a large amount of emotional work to “survive and thrive in exclusionary environments” (p.754). The power the less peripheral members held led both Ethan and Amira to question the own legitimacy in the community, leading to additional emotional work as they engaged in the practices of the mathematics research community.

Conclusion

Underrepresented minority mathematics majors described experiences related to power and identity as they navigated the mathematics research community. As they interacted with peers, these students questioned their own identity as a member of community. In particular, peers who belonged to the dominant group or with greater achievement in the mathematics research community had power to grant to rescind these students’ legitimacy to the community.

Future work will explore the ways in which these students described their entrance into the mathematics research community. Specifically, why they chose to join the community and how they experienced gaining access to the community. In addition, future work will examine the students' access to *mirrors* (Gutierrez, 2012) with which to see themselves in the mathematics research community.

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