Factors Shaping Community College Math Major Motivations and Persistence in Mathematics

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Given declining numbers of undergraduate students choosing to major in mathematics, research in undergraduate mathematics education seeking to understand the motivations and perceptions of math majors is more important than ever before. Of particular interest in this report are community college mathematics majors—they make up a significant proportion of math majors in any given year and yet existing research on recruitment and retention in STEM has been conducted almost exclusively at four-year colleges. We report findings from in-depth interviews with eight community college math majors regarding their motivations to major in mathematics. We then examine the ways in which such motivations interact with institutional and departmental structures traditionally noted to influence persistence in STEM majors. We discuss implications for improving math major retention and advancing the field's understanding of the influence of collegiate context on perceptions of mathematical culture.

Keywords: community college, math major, motivations

The declining number of undergraduate students choosing to major in mathematics—and ultimately graduating with a mathematics degree—has been cause for increasing concern both within U.S. mathematics departments and worldwide (Hall et al., 2022; Musu-Gillette et al., 2015; Seymour & Hewitt, 1997; Seymour, Hunter & Weston, 2019). However, most research collapses math majors within the umbrella of "STEM" or "math and science majors" (see Seymour, Hunter & Weston, 2019 for an overview) and thus is too broad to describe challenges specific to the mathematics major. Some research on STEM majors investigates the influence of high school mathematics achievement (e.g. Wang, 2013; Trusty, 2002) or specific first or second-year mathematics courses on student persistence (e.g. Ellis, Fosdick & Rasmussen, 2016); however, such information is likely not enough to understand phenomenon regarding recruitment and retention of mathematics majors specifically (Hubbard, 2023) given that they interact far more frequently with mathematics departments compared to other STEM majors.

Moreover, the majority of research on recruitment and retention in STEM fields has been almost exclusively conducted at four-year colleges. Little is known about community college STEM majors, and even less about community college mathematics majors (Mesa, Wladis & Watkins, 2014). This is problematic given that almost half of all mathematics majors in a given year are enrolled in community colleges (NCES, 2020), and roughly half of all graduates from four-year colleges at started at a community college (Foley, Milan & Hamrick, 2021). Thus, community colleges are a critical yet understudied part of the math major pipeline.

Of particular interest to recruitment and retention of community college math majors are students' motivations for majoring in mathematics, and how these motivations are influenced by institutional experiences (Wang, 2013). In this report, we asked:

1. How do community college math majors describe their motivations for majoring in math?

2. In what ways are institutional and departmental structures in alignment or tension with these motivations?

The data from this report comes from eight in-depth interviews with students majoring in math as of summer 2024 and enrolled in a two-year college within the City University of New York (CUNY) system. This data is part of a larger mixed-methods project that seeks to identify factors that impact community college math major recruitment and retention, and to create the first retention model for community college mathematics majors. In answering the research questions noted above, we seek to contextualize the field's understanding of the motivations of math majors for pursuing mathematics, and to provide hypotheses regarding the mechanisms by which such motivations might interact with larger structural factors within a math department.

Literature Review

Tinto's model of student departure (Tinto, 1987) is arguably the most influential existing model of college student retention in the literature. Tinto posited that family background, pre-college schooling, and individual student attributes influence student persistence via two "integration" variables which impact a student's decision whether or not to drop out. These variables are 1) academic integration, often measured by course grades; and 2) social integration, often measured by frequency of interaction with other students and faculty. However, subsequent literature has critiqued the relevance of Tinto's model for community college students and other "non-traditional" students (Bean & Metzner, 1985; Ashar & Skenes, 1993; Borglum & Kubala, 2000; Karp, Hughes & O'Gara, 2010; Stuart, Rios-Aguilar & Deli-Amen, 2014).

Bean and Metzner (Bean & Metzner, 1985) developed a model for retention of "non-traditional" adult learners (either over 24 years old, a commuter student, and/or a part-time student) that primarily focused on an institution's academic utility rather than its social environment. The authors contend that social integration is significantly less influential for such students, given that they likely enter higher education with their own support systems and social networks. Their model of student attrition contains three main variable categories: environmental, academic, and background, and these variables then influence academic and psychological outcomes, which in turn determine a student's decision to persist. While this model may be more relevant for groups of community college mathematics majors, it still is not designed to examine the particular interactions between students and mathematics departments and courses that are likely to be relevant to improving math major retention specifically.

Given the limitations of both existing models described above, we focus our review of the literature on variables relevant to retention of mathematics majors. Literature specific to retaining mathematics majors is slim, so we supplement the current review with literature on the more general category of STEM major retention. Within this literature, there are several key factors noted to influence STEM major retention. Most of this work has been conducted in four-year contexts (Wang, 2021), which focuses on factors such as grades and disposition towards mathematics in high school (Musu-Gillette et al., 2015; Shaw & Barbuti, 2010; Wang, 2013; Trusty, 2002; Evans, Chen & Hudes, 2020) and perceptions of mathematics self-efficacy or self-concept once taking college courses (Ellis, Fosdick, & Rasmussen, 2016; Wang, 2013). Though we do not attempt a comprehensive overview of all relevant factors here, we see three overarching categories from existing literature as relevant to our core constructs: sense of belonging and social integration (Rainey et al., 2018; Tinto, 1987; Rodriguez, & Blaney, 2021; Good, Rattan & Dweck, 2012); engagement with undergraduate research opportunities (Russel, Hancock & McCullough, 2007; Eagan et al., 2013; Seymour et al., 2004; Hunter, Laursen &

Seymour, 2007); and mentorship (Apriceno, Levy & London, 2020; Atkins et al., 2020; Chelberg & Bosman, 2019).

In general, the presence of each of these three factors has been associated with increased persistence in STEM degree attainment, while their absence contributes to attrition. Research in the area of sense of belonging notes how both institutional cultures and student-to-student interactions can influence students' perception that they fit in or belong within their chosen STEM major. The underrepresentation of women and students of color in STEM, in particular, can reduce their sense of belonging which can be improved or exacerbated by the institutional and pedagogical environments at the college (Rainey et al., 2018; Rodriguez & Blaney, 2021; Good, Rattan & Dweck, 2012).

Research on participation in undergraduate research experiences (UREs) and engaging with faculty mentorship has also consistently reported positive impacts on STEM major retention and subsequent interest in STEM careers (Seymour et al., 2004; Eagan et al., 2013; Apriceno, Levy & London, 2020; Atkins et al., 2020; Chelberg & Bosman, 2019). For example, Russell, Hancock & McCullough (2007) surveyed over 4000 STEM majors concerning their experience with UREs associated with the National Science Foundation and found that participation in such programs was associated with increased interest in STEM careers and graduate school. Participation in UREs and involvement with mentorship are also likely to contribute to students' sense of belonging. For example, Hunter et al. (2007) reported that UREs fostered a sense of belonging to students' desired scientific discipline and helped them to "[feel] like a scientist," (p. 53). However, given that the majority of existing research was conducted with STEM majors in four-year institutions, it remains an open question the extent to which community college math majors may perceive such resources as useful or accessible within their institutional context. The current study aimed to investigate exactly this question.

Theoretical Framework

To structure our investigation of community college math majors' motivations and the interaction of those motivations with institutional and departmental features, we turned to Critical Bifocality as it has been conceptualized and operationalized for use in mathematics education research (Chen & Horn, 2022). Traditionally, Critical Bifocality is a theoretical perspective that posits that investigations into social processes of marginalization or oppression necessitate a bifocal approach-focusing on the relationship between individual agency as well as structural features of environment. While we do not claim that the experience of being a math major in a community college context must necessarily entail marginalization or oppression, community college students are more likely compared to four-year college students to belong to groups not historically represented in higher education (Goldrick-Rab, 2007) and community colleges (and the students who attend them) have traditionally been stigmatized within higher education (Gauthier, 2020). Combined with the fact that we were interested in examining interactions between individual motivations and institutional/departmental structures, this led us to believe that utilizing the lens of Critical Bifocality would allow us to attend to the most relevant constructs for our student population.

Chen and Horn (2022) provide four principles that characterize research in mathematics education that take such an approach. Although all four principles were instrumental in informing the larger project, for the sake of space we focus the current discussion on two of the principles that were most useful for informing the data discussed in this report. They are, "(1) analyzing interactions between structures and lives; while (2) recognizing the pervasiveness of oppressive structures," (p. 802). Here, we report findings that speak to both of these principles—

individual student motivations for majoring in mathematics and influences from interactions with departmental and institutional structures.

Methods

In summer 2024, we invited all current math majors enrolled in any community college within the City University of New York (CUNY) system to participate in a paid one-hour interview about their experiences in the major. Eight agreed to participate; they varied on a range of characteristics including age, whether they were enrolled part time (PT) or full time (FT), and whether they had ever transferred from another college prior to the interview (see Table 1).

Table 1. Descriptive Characteristics of Interview Participants

Participant ID	Age	Gender	Last math course(s) completed prior to interview	Enrollment intensity	History of transfer
1001	44	Man	Calculus I	PT	yes
1002	29	Man	Calculus III, abstract algebra, differential equations	FT	yes
1003	24	Woman	Calculus I	FT	yes
1004	26	Woman	Precalculus	PT	yes
1005	22	Man	Calculus I	FT	yes
1006	25	Man	Abstract algebra	PT	yes
1007	21	Man	Calculus III, linear algebra, abstract algebra	FT	no
1008	23	Man	Calculus I	FT	no

Each interview was guided by a semi-structured protocol that consisted of the following topics: rationale behind major choice; course-taking (including placement); perceptions of quality of instruction in college math courses; influences of external life factors such as work, family, and health/disability; and influences of institutional culture, structures and resources on persistence within the major. The data for the current analysis is drawn from questions regarding students' motivations to major in mathematics as well as a segment of the interview in which students were specifically asked to comment on their use and perceptions of institutional features commonly noted as influencing persistence in STEM majors in the broader literature (undergraduate research opportunities, mentorship, and community involvement). Influences from students' environmental life factors were also important, but are beyond the scope of this report.

Analysis

Each interview was recorded and transcribed, then coded in several stages using thematic content analysis (Braun & Clarke, 2006). First, five researchers read all transcripts and met to generate common emergent themes. For example, at this stage researchers agreed that there was an important theme regarding students' motivation to major in mathematics and the notion of "real world applicability"; however, the exact definition of "real world" was not yet precisely specified. Then, two researchers took the generative initial themes, reviewed and refined them, and developed a more nuanced set of subcodes. For example, some students were motivated to major in in mathematics due to advancements that such a degree would provide for them in their current or former job. Still others noted that their motivation stemmed from a broader appreciation for the relevance of mathematics in explaining phenomenon occurring outside of college classrooms. This was carried out in a number of cyclical rounds until consensus was reached between the two coders about the subcodes and the definitions of the overarching themes. Then the final list of themes was shared with a third researcher (another of the original five) for further discussion and refinement, leading to final thematic analysis results presented here.

Results

One prominent theme that emerged from the student interviews was that most community college math majors in the sample were interested in mathematics primarily for its utility, often favoring applied over pure mathematics. Seven of the eight participants shared that they felt that majoring in mathematics would be beneficial because it would facilitate advancement in their current careers (1001, 1003, 1004, 1005) or prepare them for success after transferring to a bachelor's or graduate degree program (1002, 1005, 1007). In contrast, one participant (1006) reported choosing the mathematics major because they aspired to become a mathematician. Overall, participants expressed greater appreciation for applied or "practical" aspects of mathematics than for purely theoretical ones.

However, students frequently felt conflict between their orientation around the practical aspects of mathematics and their experiences of the structure and culture of mathematics departments and classes, where they felt that pure mathematics was the prevailing norm. Two subthemes emerged within this broader theme: one concerning how students experienced this mismatch within their mathematics courses, and another addressing how the mismatch was perceived in extracurricular mathematics contexts, including math clubs, research opportunities, and internships.

Conflict Between Students' Motivation and Course Structures and Culture

1005 illustrated this conflict when describing what an ideal experience would be like within the math major, stating that most of what he would learn would be about, "not just solving maths, they will be able to teach you how to apply this mathematics into the work field...Because like I said, learning how to solve [for] x and y is not enough...I want to know how to use this stuff out there [in the workforce]." In this way, 1005 contrasts purely theoretical aspects ("just solving maths") with those practical aspects that would support him in his transition into the workforce.

Although career relevance is a motivation that has been reported by retention literature focusing on non-traditional students (e.g. Bean & Metzner, 1985), participants occasionally provided evidence that they viewed this common practice-orientated motivation for majoring in math as contrasting with the motivations of a "typical" mathematics major or of the mathematics instructors they have interacted with. This contrast was well-illustrated by 1002, who was set to graduate with their associate's degree in mathematics after the semester in which they were interviewed. When asked about what kind of mathematical activities they enjoyed, they responded, "There are people who love math ... I am not one of them, for sure... The people who love math, who are deep into the most abstract imaginary concepts that are applicable maybe in like 500 years or something… that's just not me." Although 1002 went on to say they do like mathematics, they saw this form of liking as outside of the norm for the motivations of a typical mathematics major because it does not privilege abstract ways of thinking.

1007, who was also set to graduate with their associate's degree in mathematics that semester, expressed similar views. They stated, "I guess I'm not really like those kind of mathematicians where they...see this simple thing and then they'll just devote their couple years to that thing. And in the end, it's just for curiosity... I actually wanted to see something, how I can use math in the real world." Here, 1007 draws a contrast between himself and "those kinds of mathematicians" in which his interests in more broad applications of mathematics are seen as distinct from topics that would be of interest within a dissertation or academic research article. These findings both align with existing literature (which have noted the importance of real-world relevance and applicability to community college students) and add nuance specific to mathematics majors. In particular, students appeared to make sense of their belonging within a departmental culture they perceived as privileging pure and theoretical mathematics over practice-oriented, applied mathematics. This perception, in turn, seemed to undermine students' sense of belonging in the major. Whether and to what extent such departmental cultures contribute to students' decisions to leave the major remains an open question that we focus on in future phases of this project.

Conflict Between Students' Motivation and the Structure and Culture of Extracurricular Mathematics Activities

Beyond their coursework, many students noted that extracurricular mathematics opportunities also conflicted with their mathematical interests, and subsequently influenced their sense of belonging in the major. Among the seven who reported motivations for majoring in mathematics relating to practicality or their interest in applied fields, it was common for participants to report a feeling of misalignment with institutional resources such as internships, or departmental resources such as social math clubs and undergraduate research projects. For instance, both 1007 and 1003 reported having an initial interest in joining a social math club, but each mentioned a hesitation in participating because they felt these clubs were intended more for students interested in pure mathematics. For 1003, the computer science club felt "more accessible" than the math club, and so she chose to "attack [math] from the lens of computer science" instead. Likewise, 1007 expressed reservations about the mathematics faculty member leading the math club as someone who graduated from an elite institution of higher education with a mathematics degree. He felt that he was more easily able to communicate with a different math club facilitator, who, "might not be the most intelligent or like most successful who graduated from, I don't know, MIT, Caltech, NYU, but the way they communicate with students, the way they engage with students are the best...I guess those kind of professors at math clubs, I think those would be really enjoyable." In this way, we see students' perceptions of their own motivations interact with this structural feature of their mathematics department. In this case, these motivations are perceived as being in conflict with their perceptions of these opportunities, which thus influences students' sense of belonging and subsequently their participation.

In contrast, 1006, who was motivated to major in math in order to become a mathematician, utilized a variety of departmental resources, including his institution's math club and a summer research experience for undergraduates (REU). 1006 reported engaging in these opportunities due to the connection he felt to the other students and faculty members that participated in them. He perceived these individuals as those who, like himself, "also want to talk about [math] problems for the sake of just talking about the problems instead of just going to get the grade." He explained further, "you find people like that sometimes in your classes as well. So, Math Team, certain classmates in my classes who also actually enjoy what they're doing make me feel like I belong." 1006 described math team as "where the mathematician math majors go" in contrast to math majors interested in other applied disciplines. In this way, 1006 saw his motivations as in alignment with his perceptions of these departmental resources, which further supported his perception of belongingness within the major. We see such findings as in alignment with other work demonstrating the potential for mathematics departments to reinforce exclusionary assumptions of not only who is welcome in mathematical spaces, but what kind of mathematics is welcomed into those spaces (Rodd & Bartholomew, 2006; Battey & Leyva, 2016).

Conclusions and Implications

The broader project from which these data were drawn aimed to generate hypotheses about ways that existing retention literature may fail to fully capture the experiences of community college mathematics majors. Our first finding indicated that students were frequently interested in mathematics because of its perceived utility and applicability to applied problems. Students described this practicality in multiple ways, including the utility of mathematics for career goals or future fields of study, as well as the applied, problem-solving aspects of mathematics courses themselves. In particular, students often viewed this preference for utility as in conflict with a dominant mathematics higher education culture that they perceived as prioritizing pure mathematics, done for its own sake, as a core ideal. This feeling of conflict with mathematical norms appeared to reduce many community college mathematics majors' sense of belonging.

This sense of conflict and misfit occurred both within students' mathematics courses, and within extracurricular mathematics activities offered by the mathematics department, such as the math club, the math team, and undergraduate research opportunities.

These findings illustrate how students' motivations for majoring in mathematics may interact with structural features of mathematics departments in ways that generate either conflict or alignment. This highlights a potential mechanism through which college mathematics culture may play a critical role in shaping community college mathematics majors' sense of belonging, both within the major and the broader mathematical community. We view the cases presented here as an example of Critical Bifocality, illustrating the relationship between individual experiences and departmental structures that may be uniquely intensified in the community college context.

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