Investigating STEM Retention Program Participants' Sense of Belonging in Mathematics

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Research suggests that a sense of belonging in mathematics can influence students' decisions to persist in STEM fields. Programs such as summer bridge programs and Louis Stokes Alliances for Minority Participation (LSAMP) programs are often utilized to promote STEM retention by helping students adapt to college STEM environments. This study explores the mathematics sense of belonging and identity of students in STEM while participating in an LSAMP program after their participation in a summer bridge STEM program. Survey and interview data from the students will be analyzed to identify how participation in STEM retention initiatives may have influenced their mathematics sense of belonging and identity. After taking their first summer mathematics course, students' overall sense of belonging in mathematics appears to decline, according to initial findings. Results of this study also suggest that having interpersonal relationships allowed one student to have an increased sense of belonging in mathematics.

Keywords: sense of belonging, identity, retention, diversity, bridge programs

Students often leave science, technology, engineering, and mathematics (STEM majors) after taking mathematics courses within the first two years of college (e.g., Chen et al., 2013), and historically underrepresented college students are less likely to persist in these areas compared to their peers (e.g., Alkhasawneh & Hobson, 2011). A sense of belonging in mathematics may improve students' desire to persist in STEM (Good et al. 2012), so programs that support the development of a mathematics sense of belonging could be a critical component of STEM retention. LSAMP programs and summer bridge programs contribute to retention efforts of underrepresented STEM students through diverse representation, community, mentorship, and tutoring. However, little is known about how these programs influence mathematics sense of belonging. This project explores the development of participants' sense of belonging, confidence, and identity in mathematics after their involvement in STEM programs. In particular, I ask:

1. How does the mathematics sense of belonging of STEM retention program participants change or differ throughout their participation in these programs?
2. What aspects of bridge programs do participants value and why? How do these valued aspects relate to their sense of belonging in math?

I will answer these questions using student surveys and interviews. These research questions are part of a broader study that also includes program center observations and staff interviews.

Literature Review

Historically underrepresented students (African Americans, Hispanic Americans, Native Americans, and women) are less likely to persist in STEM areas in comparison to their counterparts at the postsecondary level (Alkasawneh & Hobson, 2011; Riegle-Crumb et al., 2019). These students are also less likely to have a sense of belonging in STEM (Rainey et al., 2018). There are many factors, such as climate, lack of representation, and students not having a sense of belonging, that impact the persistence of underrepresented students in mathematics and cause higher attrition rates in STEM (Botella et al., 2019; Chen, 2013; Meador, 2018; Strayhorn, 2012). Postsecondary institutions offer a variety of resources, such as mentoring, tutoring, and supplementary instruction, to help address attrition among underrepresented students pursuing

STEM degrees. STEM retention programs, such as summer bridge programs and academic year support programs, are one way to improve retention in STEM by helping students transition into college STEM environments by offering academic and social experiences, creating a community-oriented environment for underrepresented STEM students to thrive in. Investigating and understanding students' experiences in STEM retention programs can be important for teaching, learning, and retention in STEM.

Research shows that a low sense of belonging (Ahlqvist et al., 2013) and STEM majors leaving these disciplines when taking mathematics courses during the first two years of college (Chen et al., 2013; Seymour & Hunter, 2019) contribute to attrition in STEM. Little is known about how specific environments, such as STEM retention programs, contribute to retention in STEM through mathematics sense of belonging. Towards these ends, this study aims to explore students' mathematics sense of belonging, mathematics confidence, and mathematics identity development while participating in a STEM retention program.

Academic and Social Integration

Research has revealed that the first year of college is a critical period for attrition in STEM (Chen, 2013), particularly as the transition to college involves students negotiating both academic and personal stressors (Ruble & Seidman, 1996). Fostering a stable environment during students' transitions to undergraduate studies can be crucial to their college success.

Sense of Belonging in Mathematics

A sense of belonging can be described as the perception of social support among students on campus and the experience of mattering or feeling valued by and essential to a certain group; this is important for underrepresented students pursuing STEM (Strayhorn, 2012). Meehan et al. (2018) used Good et al.'s (2012) sense of belonging in mathematics (SBM) measure to examine the impact that the transition from secondary school to university mathematics has on students' SBM. Their study also reveals that a growth mindset, meaning that abilities can be developed, instead of mathematics ability being a fixed trait, seemed to help students navigate the mathematical transition (Meehan et al., 2018).

Mathematics Identity

Mathematics identity also impacts students' desire to pursue and persist in STEM areas (Black et al. 2009; Cribbs et al., 2021) and refers to one's perceptions of their own relationship to mathematics (Cribbs et al., 2015). To further elaborate, mathematics identity shapes how students view their abilities, experiences, and potential within the field of mathematics, ultimately influencing their confidence.

STEM Retention Programs

Goff et al. (2019) report how informal education programs can serve as a resource to improve STEM retention through impacting students' interest in mathematics. Their findings show that students who participated in informal science and mathematics environments feel more competent in STEM and report increased interest and greater engagement in STEM areas.

For students from groups historically underrepresented in STEM, two common types of models of STEM retention programs are Bridge programs and LSAMP programs. Bridge programs often focus on underrepresented students, first-generation students, low-income students, or students pursuing specific degrees (Kallison & Stader, 2012). The socially

supportive components of bridge programs include faculty mentoring, peer tutoring, peer mentoring (Bradford et al., 2021). LSAMP programs were developed in reference to Tinto's (1975) model for retention (Clewell et al., 2006) and are specifically tied to STEM retention with an emphasis on supporting historically underrepresented groups in STEM (Clewell et al., 2006).

Theoretical Framework

This work is grounded in the academic and social integration components of Tinto's Conceptual Schema for Dropout from College (1975), which identifies academic and social systems as contributors to one's dropout decision. This theoretical framework has been widely adapted for researching retention in STEM.

Methods

Data were collected using surveys and semi-structured interviews. The survey instrument included the 30-item Good et al. (2012) sense of belonging in mathematics scale, the six-item Lubienski et al. (2021) mathematics confidence scale, and short answer questions about students' identity and sense of belonging in math. A coding scheme for belonging explanations, adapted from Rainey et al. (2018), was used for initial content analysis and coding reasons such as mathematics identity, interpersonal relationships, personal interest, or competence. I used qualitative analysis methods and descriptive statistics to produce results. I describe this in further detail in the analysis section.

Studies have demonstrated that students need social integration, academic support structures, and sense of belonging to persist in STEM (Tomasko et al., 2016; Rainey et al., 2018). This study takes a closer look at sense of belonging among historically underrepresented students in STEM, specifically in relation to their mathematics experiences, as many mathematics courses are one of the first courses that undergraduate STEM majors encounter as a prerequisite for undergraduate STEM coursework. To do so, this study will examine how mathematics sense of belonging, mathematics identity, and mathematics confidence may differ over the course of one semester of participation for students who participated in two preparation programs intended to support historically underrepresented students in STEM fields**.**

Student Surveys

Bridge participants and LSMAP participants were surveyed about a variety of topics, with the goal of understanding students' mathematical sense of belonging, mathematics confidence, and mathematics identity, and the underlying factors that may contribute to these affects. They were surveyed at three points during the school year—once within the first month of semester 1 (Survey 1), once during the last two weeks of the semester (Survey 2), and lastly at the end of semester 2 (Survey 3). E-mail addresses were collected via the surveys to link the surveys and to schedule interviews with those who indicated interest. The surveys contained scales to measure students 'mathematics sense of belonging, mathematics confidence, and mathematics identity. The Good et al. (2012) 30-item Math Sense of Belonging scale was used to measure students' sense of belonging.

Student Interviews

Students were interviewed mid-semester 1, at the end of the semester 1, and at the end of semester 2 about their mathematics sense of belonging and mathematics identity for about 30 minutes each time. Questions focused on asking students to reflect on their trajectory toward pursuing their selected undergraduate degree program and to understand participants' history

with mathematics and mathematical role models. They were also asked to reflect on their bridge program or LSAMP experience to gain insight into their experiences in these STEM retention programs. Finally, participants were asked questions regarding their feelings of belonging, identity, and confidence in mathematics to gain an understanding of the students' beliefs about belonging in math and how they view themselves in mathematics. Student interviews were conducted using semi-structured format that involved me asking interviewees open-ended questions and following them up with probe questions to explore more about their experiences. (Roulston, 2013).

Planned Analysis

The descriptions of my planned analysis are written in the future tense because I have only recently started. All data, however, has been gathered prior to this proposal submission.

Research Question 1

How does the mathematics sense of belonging of STEM retention program participants change or differ throughout their participation in these programs? To analyze the survey responses to the mathematics sense of belonging scale, I will determine Likert scale total scores, frequency of each Likert scale score, and Likert scale mean scores to run dependent t-tests to calculate the mathematics sense of belonging mean scores at time point 1 and time point 2. Descriptive representations will aid in representing the comparisons between the results found at both time points by displaying how mathematics sense of belonging may change over time.

To analyze the interviews and open-ended survey questions, I will use line-by-line content analysis at the sentence or sentence cluster level (Schreier, 2014). The goal of this analysis process is to reveal themes found throughout the participants' responses about their sense of belonging in the open-ended survey questions and interviews. I will be looking for positive and negative connotations of sense of belonging in mathematics using a coding scheme adapted from Rainey et al. (2018).

Table 1. A table showing a summary of the Rainey et al. (2018) coding scheme..

Coding Scheme for Belonging Explanations
(Rainey et al., 2018)

Code	Reason for Belonging	Reason for not Belonging
Interpersonal Relationships	Feels socially connected with peers and/or faculty members.	Lacks a social connection with peers.
Math Identity	Math is a part of their identity as a person.	Lacks a personal connection to the major or material
Personal Interest	Expresses personal interest in course subject or major.	Explicit lack of interest. May find the material boring
Competence	Feels like they understand material or receives good grades	Feels like they do not understand material well

Research Question 2

What aspects of bridge programs do participants value and why? How do these valued aspects relate to their sense of belonging in math? Line-by-line content analysis will be used

to analyze each sentence or sentence cluster of the interview data collected to find what students value most while participating in these programs (Schreier, 2014). The interviews will be analyzed for most mentioned aspects of the LSAMP program that students believe impact their feelings of belonging in mathematics. I will be looking for connections between participants' responses. I will also use some of the initial coding to make sense of broader patterns and find themes of what students value most using open coding (Khandkar, 2009). Moreover, the Rainey et al. (2018) coding scheme, which will identify students' reasons for belonging, will provide insight into how these valued aspects relate to their mathematics sense of belonging.

Preliminary Results and Conclusions

Participants' feelings of membership and acceptance as measured by the Good et al. (2012) sense of belonging in mathematics scale, declined between the start and end of the summer bridge program. However, this decrease may be attributed to the intensive nature of summer courses. Despite these challenges, students valued the mentoring and program components.

Interviews with one participant revealed confidence in their sense of belonging in mathematics with the reasoning being personal interest and competence, often feeling reassured by peers and mentors in the program. Initial findings indicate a decline in students' overall sense of belonging in mathematics after their first college summer mathematics course. Yet, the positive experiences with the bridge program suggest that continued participation may lead to an improvement in their sense of belonging over time. Furthermore, the results of this study so far also suggest that having community and peer interactions allowed the student to have an increased sense of belonging in mathematics. These findings offer insight into the role that STEM retention programs play in fostering diversity within STEM through the lens of an individual students' mathematics experiences.

It will be interesting to see how the findings might evolve following their participation in a STEM retention program throughout the school year.

Next Steps and Questions

Although all data have been collected, analysis has just begun at the time of submitting this proposal. Thus, there only preliminary results to share. Next steps include completing the analysis before the conference in February, at which time I expect to provide further results and conclusions. More specifically, these steps include completing more rounds of coding to draw conclusions from interview data and open-ended survey questions. I plan to also establish connections among students' sense of belonging in mathematics, mathematics identity, and mathematics confidence.

Audience Questions

1. What role do you see institutional factors such as curriculum design, faculty support, or student programs playing in fostering a sense of belonging in mathematics?
2. Can you discuss any specific interventions or strategies you found that were particularly effective in enhancing the sense of belonging of students in your mathematics courses?
3. What are some ways educators and institutions can better assess or measure a student's sense of belonging in mathematics in real-time?
4. Can you think of other frameworks I should consider using to examine this data?

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