SENSE OF BELONGING OF BLACK AND LATINA FEMALE STUDENTS IN GATEWAY MATHEMATICS CLASSES: A MIXED METHODS STUDY AT A MINORITY SERVING INSTITUTION

by

SARAH HYONSUK PARK

(Under the Direction of Amy B. Ellis)

ABSTRACT

This sequential explanatory mixed methods study examined Black and Latina female students' sense of belonging in gateway mathematics. Using the theoretical perspectives of intersectionality, sense of belonging, and authorizing student perspectives, I explored how students' intersectional identities shaped their belonging experiences in college algebra and precalculus courses. Conducted at a diverse, public open-access minority-serving institution, this study provides unique insights into belonging experiences within a racially diverse mathematics classroom environment and offers critical understanding of belonging in an underexplored educational context.

In the quantitative phase, I surveyed 1,136 students (pre-survey) and 639 students (post-survey) using demographic questionnaires and an adapted Sense of Belonging Scale. I conducted ANOVA and ANCOVA analyses to examine belonging differences and changes across racial and gender groups. In the qualitative phase, I conducted interviews with 13 Black and Latina female participants and collected 11 mathematics autobiographies. I analyzed the qualitative data using reflexive thematic analysis.

Quantitative results revealed comparable belonging scores across demographic groups, with only one significant difference: Latina female students reported slightly lower pre-belonging scores than Black male students. Mathematics affinity and expected grades were significantly associated with belonging rather than race or gender, while faculty significantly influenced belonging changes.

From the qualitative findings, I identified six factors that positively influenced belonging: professors' mathematical microaffirmations, perception of professors as caring, encouragement of peer collaboration, peer connections, positive mathematics self-efficacy, and classroom diversity. I also identified six factors that negatively influenced belonging: professors' mathematical microaggressions, perception of professors as uncaring, limited peer collaboration, lack of peer connections, negative mathematics self-efficacy, and past negative mathematics experiences.

Through integration of findings, I found that in this diverse institution, students' mathematics self-efficacy and faculty-student relationships were more salient to belonging in than racial or gender identity. Students created peer support systems serving as buffers against negative belonging factors. Belonging requires intentional, sustained faculty efforts including mathematical microaffirmations, collaborative learning structures, and individualized support.

These findings contribute to understanding the sense of belonging in diverse mathematics classrooms and provide practical implications for creating inclusive learning environments where all students can develop a strong sense of belonging in mathematics courses.

INDEX WORDS: Sense of Belonging, Black and Latina Female Students, Gateway Mathematics Classes, Intersectionality, Minority-Serving Institutions, Mathematics Self-Efficacy, Mathematical Microaffirmations, Mathematical Microaggressions, Faculty-Student Relationships, Peer Connections

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DEDICATION

To my mother, Hye Y. Moon, whose boundless love, wisdom, and warmth have shaped every part of who I am. Your belief in making others feel seen, valued, and cared for has been one of my greatest lessons.

And to every student who has ever felt out of place or unseen: You belong, you matter, and you are worthy.

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CHAPTER 1

INTRODUCTION

Higher education institutions are becoming increasingly diverse in their undergraduate populations, but gender and racial disparities in STEM (Science, Technology, Engineering, and Mathematics) education persist. In particular, minoritized female students, especially Black and Latina women, continue to be underrepresented in almost all STEM fields relative to their share of the population. This is particularly salient when they are compared to their White female and minoritized male counterparts, despite increases in degree attainment and decades of research and efforts to increase participation (Espinosa, 2011; Johnson, 2012; Ong et al., 2016). Moreover, these disparities persist even after controlling for factors such as high-school preparation and intent to study STEM (Hatfield et al., 2022). Although minoritized female students often begin college with a strong interest in STEM, a large proportion leave the major during the introductory STEM course experience due to an environment that is unsupportive, exclusionary, and unwelcoming (Johnson et al., 2007; Ong et al., 2011; Hatfield et al., 2022). Minoritized female students are more likely to experience both gendered and racialized experiences in mathematics classrooms due to the "double bind," i.e., their intersecting racial and gender identities (Leyva et al., 2020; McGee & Bentley, 2017; Ong et al., 2011; Museus et al., 2011).

Introductory mathematics courses can serve a gatekeeping function, preventing students from progressing in STEM programs especially in open-access institutions (Seymore and Hunter, 2019). Open access institutions are colleges that are nonselective in their admission standards and provide increased access to higher education for diverse populations (Anderson, 2015), especially Black and Latinx students (Rendon, 2020). College algebra, the typical gateway course at open access institutions, has been shown to act as a barrier in students' STEM pathways (Herriot & Dunbar, 2009; Gordon, 2008; Cohen & Kelly, 2019). National pass rates in college algebra are dismal; each year only about 50% of students earn passing grades in the U.S. (Saxe & Braddy, 2015). This is particularly concerning because gateway mathematics courses, such as college algebra, are important factors in student retention efforts at open-access institutions, as performance in these courses is strongly correlated with STEM retention and degree completion (Hatfield et al., 2022; Barnett, 2011a; Palmer et al., 2010). Minoritized female students face an additional burden in these STEM introductory courses, as they navigate experiences of isolation, bias, racial and gender microaggressions, stereotype threat, and lack of belonging (Leyva et al., 2020; Jett, 2019; McGee, 2016; Martin, 2009; Ong et al., 2011; Booker, 2016).

Researchers argue that sense of belonging at the classroom level, in particular, is a key factor in supporting minoritized student persistence, and it may even improve academic performance (Kirby & Thomas 2021; Wilson et al., 2015; Freeman et al., 2007). For instance, one large-scale study showed that across five institutions, classroom-level belonging was strongly associated with both student engagement and success in STEM (Wilson et al., 2015). This sense of belonging may be influenced by multiple factors, including peer interactions/relationships, instructor support, microaffirmations, academic self-efficacy, and intersectional identities (Demetriou et al., 2023; Rainey et al., 2018; Wilson et al., 2015; Zumbrunn et al., 2014). However, female minoritized students are less likely to report feeling a sense of belonging in STEM and more likely to report a decrease in their sense of belonging throughout the semester (Rainey et al., 2018). Consequently, women are more likely to exit STEM because they do not feel welcomed or valued by others (Good et al., 2012; Seymore and Hewitt, 1997). Understanding female minoritized students' sense of belonging, therefore, is a key aspect in better understanding their academic experiences in STEM, and by extension, understanding how to better support their persistence and achievement (Hurtado et al., 2015; Strayhorn, 2019; Johnson et al., 2007; Museus et al., 2017; Locks et al., 2008).

There are few studies on mathematics classroom-belonging that consider race or gender, and even fewer that address the intersection of these dimensions. Studies on women's sense of belonging that do not consider racial identity may not represent the experiences of minoritized students, and studies that only analyze racial identity may fail to encompass the unique experiences of female students. The limited studies that do analyze the intersection of gender and racial identities are primarily situated in Predominantly White Institutions (PWI) or Traditionally White Institutions (TWI), highly selective universities, or a few Historically Black Colleges and Universities (HBCUs), but not in diverse, open access institutions (Battey et al., 2022; Leyva et al., 2021; Johnson, 2012; Perna 2010). The institutional context may influence how race and gender interact with other factors to shape students' belonging experiences. Furthermore, the majority of belonging studies in postsecondary settings consider sense of belonging at the campus or departmental level, rather than at the classroom level. The field needs more work addressing the intersection of race and gender in considering students' sense of belonging, particularly given the critical need to better support female minoritized students' undergraduate STEM experiences.

In my dissertation study, I examined how minoritized female students with intersecting racial and gender identities experience belonging, in gateway mathematics classrooms. In considering the intersectionality of race and gender, my study expands the existing body of research that typically addresses only one of these dimensions. Furthermore, I situated my study within a minority-serving, open-access institution with a racially and socioeconomically diverse student population, a context seldom considered in belonging studies. Finally, my study addressed belonging at the classroom level, rather than at the institutional level, addressing a critical need to better understand the factors that can support students' experiences in gateway mathematics courses. In doing so, my work contributes to an understanding of how to better develop classroom structures and pedagogies that foster rather than hinder students' sense of belonging in their chosen STEM field.

Research Questions

The purpose of this study is to understand how Black and Latina female STEM students experience sense of belonging in their first-year introductory mathematics courses, college algebra and precalculus, at a racially diverse, open-access, four-year public institution in the Southeast region. The following research aim will guide this study: How do their identities as Black and Latina female students play a role in their sense of belonging in gateway mathematics classrooms at a racially and ethnically diverse direct access institution? Specifically,

1. How do Black and Latina female students' sense of belonging in the college algebra and precalculus classrooms differ compared to students in other racial and gender groups?
2. How does Black and Latina female students' sense of belonging in college algebra and precalculus change from the beginning to the end of the semester?
3. How do Black and Latina female students describe their college algebra and precalculus learning environment, experiences, participation, persistence, support systems and challenges as it relates to their sense of belonging?

Researcher's Positionality

As I am responsible for interpreting the qualitative data, I will briefly discuss my positionality. I am a first-generation Asian American female doctoral student and mathematics instructor at the institution in which the study was conducted. I hold strong beliefs about the profound effects of sense of belonging and racialized/gendered classroom experiences on female minoritized students. Throughout my career, I have witnessed many female minoritized students' give up on their STEM major after struggling to pass required introductory mathematics courses. As both a mathematics instructor and a mathematics education PhD student, I believe that educators play an integral role in constructing welcoming classroom environments and incorporating inclusive pedagogical practices for all students.

Drawing from my personal experience as a Korean female student, I have felt both belonging and alienation in mathematics classrooms, but I also recognize my model minority status in mathematics education spaces due to my race. While I may share some experiences with my participants, I remain cognizant of the need to minimize my biases and remain attentive to authorizing students' perspectives.

Moreover, the faculty at this institution are my colleagues whom I consider friends. Therefore, I hold a favorable disposition towards them and believe that they have good intentions for their students and their classes. I acknowledge that this position introduces complexities that influence the qualitative analysis when students discuss their current experiences regarding their classes and faculty.

CHAPTER 2

THEORETICAL PERSPECTIVES & LITERATURE REVIEW

Theoretical Perspectives

In order to explore female minoritized students' sense of belonging and experiences in gateway mathematics classrooms, I framed my study using three conceptual frameworks: (a) sense of belonging; (b) intersectionality; and (c) authorizing student perspectives. In this section, I provide an overview of these frameworks.

Sense of Belonging

History of Sense of Belonging

The importance of sense of belonging as a conceptual framework has been well established in the literature (Ostrove & Long, 2007; Strayhorn, 2019). Maslow (1954) established belonging as a basic human need that motivates behavior and drives beliefs. In an extensive literature review, Baumeister and Leary (1995) suggested belonging as a conceptual framework to study human behavior, because the need to belong is linked to cognition, emotion, behavior, health, and well-being. Baumeister and Leary also explained that much of what we understand about human inter-personal behavior can be included under the concept of belonging and that "the most common and widespread bases of prejudice are race, gender, and national origin" (p. 521). In the school context, Goodenow (1993) found that both belonging and motivation were associated with classroom effort and achievement among middle school students. In the college context, Hurtado and Carter (1997) offered sense of belonging as a conceptual framework to understand how social and academic experiences affect racially minoritized students. Since then, researchers have connected sense of belonging to student's identity, the types of institution students attend, interaction with peers and faculty, campus climate, and positive student outcomes (Bollen and Hoyle, 1990; Hurtado et al., 2015; Strayhorn, 2012; Museus et al., 2017; Zumbrunn et al., 2014).

Definition of Belonging

The definition of sense of belonging is not consistent in the literature. According to McMillan & Chavis (1986) sense of belonging is a "feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together" (p. 9). Goodenow (1993) defined it as "students feeling accepted, valued, included, and encouraged by others in the academic classroom setting and of feeling oneself to be an important part of the life and activity of the class" (p. 25). Hurtado and Carter (1997) wrote that sense of belonging is the "individuals view of whether he or she feels included in the college community" (p. 327). Wise (2022) stated, "Belonging is being accepted and invited to participate; being part of something and having the opportunity to show up as yourself" (p. 3). Sense of belonging has also been described as the "individual's sense of identification or positioning in relation to a group or to the college community, which may yield an affective response" (Tovar & Simon, 2010, p. 200). Moreover, Rendon (2021) noted that sense of belonging can be both experienced and felt. For the purposes of this study, I will use Strayhorn's (2019) definition: "Sense of belonging refers to students' perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the campus community or others on campus such as faculty, staff, and peers" (p.4).

Prior to Hurtado and Carter's (1997) study of Latinx college students' sense of belonging, the dominant framework to explain student success in college was Tinto's (2012) theory of student integration. Tinto explained student success as a function of how well a student integrates within the institution's existing academic and social structures. Several scholars have challenged this model, because it places the responsibility solely on the student, rather than the institution, for assimilating and adapting to the institutional culture (Hurtado et al., 1997; Rendon et al., 2000; Johnson et al., 2007). Winkle-Wagner (2009), for instance, wrote that "there is an underlying assumption that a student must integrate into the institution, rather than challenging institutions to change to meet the needs of students… institutions must be willing to change, particularly when it comes to the inclusion of those from underrepresented groups" (p. 45). Research indicates institutional environments play a crucial role in shaping the educational experiences of minoritized students (Malcom & Malcom, 2011). However, Tinto's model did not fully capture the views of students from diverse ethnic, racial, economic, and social backgrounds, who may perceive and experience educational environments and interactions in distinctive ways (Bensimon, 2007; Museus et al., 2017).

The sense of belonging framework addresses these issues by affording an examination of inequalities and oppressive structures, such as the exclusion or marginalization of minoritized students. Although distinct, belongingness is often included in discussions about diversity, equity, and inclusion as it refers to the degree which people feel safe to be and express their authentic selves in a particular environment. Referring to marginalized populations, Rendon (2021) expressed that it is "imperative to get a deep, critically informed understanding of why lack of belonging remains so pervasive and what can be done to foster a greater sense of inclusion" (p. x). Lack of belonging is described as a sense of feeling invisible, alienated, rejected, or isolated from others (Strayhorn, 2019). Similarly, Wise (2022) explained that "othering" contrast belonging by "treating people from another group as essentially different from and generally inferior to the group you belong to" (p. 3). Sense of belonging becomes more significant in contexts where certain individuals are prone to feel isolated, unsupported, or invisible in environments that they experience as unfamiliar or unwelcoming (Strayhorn, 2008). Rendon (2021) stressed that the absence of belonging is not a fault of the student and requires the transformation of educational institutions. Because I will focus on Black and Latina female students, sense of belonging will be a useful framework to analyze and understand their experiences in STEM learning environments.

Strayhorn's theoretical model of college students' sense of belonging

For the purposes of my study, I will use Strayhorn's (2019) theoretical model of college students' sense of belonging, which contains the following seven core elements:

(1) Because sense of belonging is a basic human need and motivation, it is also a basic need of college students; their fundamental needs emerge in the same order as Maslow's (1954) hierarchy of needs. This need must be satisfied before any higher-order needs such as confidence and creativity can be realized;

(2) Sense of belonging can drive students' behaviors towards or against academic achievement;

(3) Belonging experiences are context-dependent and become more prominent at times and places when students (especially those who may feel marginalized) feel vulnerable;

(4) Sense of belonging is related to mattering, which is a feeling that one is valued or appreciated by others;

(5) Social identities intersect and affect college students' sense of belonging, and students experience belonging in different ways;

(6) Sense of belonging engenders other positive outcomes, such as achievement, engagement, happiness, and persistence in college;

(7) Sense of belonging must be satisfied on a continual basis and changes as circumstances and contexts change. Over time and through various experiences, students' sense of belonging in a particular social context tends to stabilize and influence their commitments and behaviors.

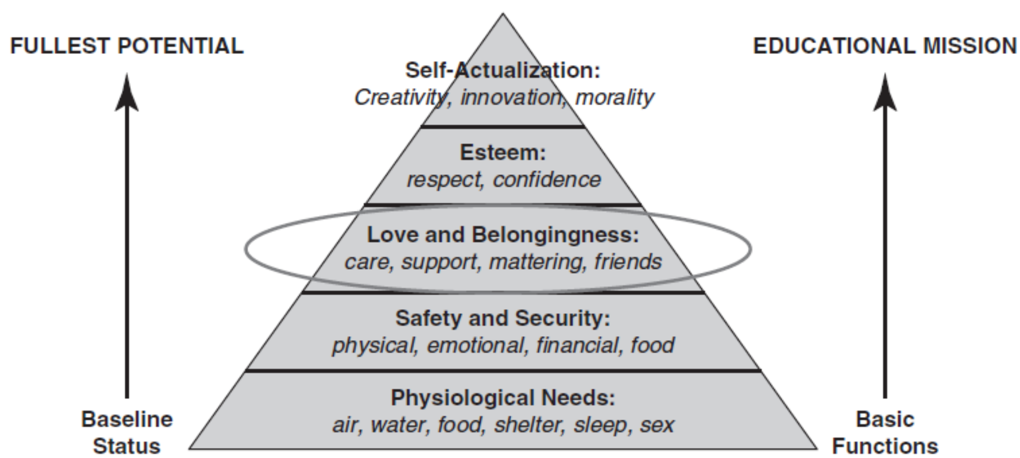

Figure 2.1 *Strayhorn's (2019, p.41) Revised Model of College Students' Sense of Belonging*

The Importance of Sense of Belonging

After basic physiological needs such as air, water, food, and security needs are met, Strayhorn (2019) stated that all of students' efforts are focused on satisfying their need to belong, as it is a basic human need, that drives behaviors and perceptions. Satisfying this need enhances a student's motivation, engagement, retention, persistence, confidence, intent to stay in the major, and academic achievement (Strayhorn, 2019; Kirby & Thomas, 2021). Therefore, students need to feel they belong in the institution, their chosen field, and especially the classrooms themselves (Grant, 2022). Depriving sense of belonging in college prevents achievement and wellbeing of students and has been linked to negative academic performance, poor persistence, poor long-term outcomes, anxiety, dissatisfaction, low self-esteem, depression and even suicide. Consequently, we need more work on understanding sense of belonging in STEM fields to focus on reducing negative outcomes among all students, especially those who face unique challenges or do not feel like they belong in STEM classrooms (Strayhorn, 2019).

Belonging and Stereotype Threat

Racial and gender stereotypes about who can be good at math greatly impact students' academic self-confidence and performance (Steele, 1997). Research on stereotype threat describes the different ways in which STEM education environments explicitly and implicitly signal threat, inferiority, and non-inclusion for historically underrepresented students (Estrada, 2019). Situations where negative stereotypes are most salient, such as STEM classrooms, may undermine a student's sense of belonging and academic performance (Barbieri & Miller-Cotto, 2021; Walton & Cohen, 2011). Negative racial and gender stereotypes send messages that certain groups are less valued, decrease students' levels of academic confidence and diminish their feelings of belonging in their STEM majors among female and minoritized students (Johnson, 2012).

Teachers may hold unconscious stereotypes of who can do mathematics in their classroom which may play out in their perception of and interaction with certain groups of students in the classroom. For example, Copur-Gencturk et al. (2019) investigated teacher bias toward students from stereotyped groups by examining K-12 mathematics teachers' evaluations of mathematics solutions to which gender and race specific names had been randomly assigned. Teachers displayed no detectable bias when assessing the correctness of students' work. However, their assessments of students' mathematical ability revealed biases against Black, Latinx and female students, with biases largest against Black and Latina female students. Interestingly, female White teachers' estimations of students' ability favored boys over girls, while non-White teachers' estimations of math ability favored White students over Black and Latinx students. Their results indicated that teachers are not free of bias, and that even minoritized teachers may be inclined to favor White, male students and have lower expectations for minoritized female students.

Belonging and Microaffirmations

A microaffirmation in an educational context is a verbal or nonverbal communication that is used to demonstrate care, acceptance, value, respect, support to students. These positive interactions include expressions of gratitude, affirmation encouragement, genuine listening, comfort, acknowledgement, and support through daily exchanges. Rowe (2008) first introduced the term "microaffirmation" defining it as, "small acts that are public and private, often unconscious but very effective which occur wherever people wish to help others to succeed" (p. 46).

Research demonstrates that microaffirmations can significantly support students who feel unwelcome or invisible, by attending to their academic, social needs and emotional well-being (D'Angelo et al., 2020). Furthermore, the conscious implementation of microaffirmation can reduce the use of and even counteract microaggressions (Boyce-Rosen & Mecadon-Mann, 2023) while disrupting systemic inequities (Ellis et al., 2019). Studies indicate that intentional acts of microaffirmations serve as powerful tools to promote belonging through positive academic performance, persistence through challenges, increased confidence, motivation, and self-efficacy (Demetriou et al., 2023). These benefits are impactful for STEM students (Estrada et al., 2019) and first-generation college students (Ellis et al., 2019).

Mathematical Microaffirmations

Mathematical microaffirmations are intentional, affirming practices that validate students' mathematical thinking and capabilities. These subtle and powerful actions or statements can contribute to the development of a positive mathematics identity and reinforce students' sense of belonging in mathematics classrooms. As Cawley and Wilson (2024) noted, individuals often remember how they felt during a mathematics class more clearly than the specific content they learned. Mathematical microaffirmations influence students' belonging experiences in constructive ways.

Cawley and Wilson identified three categories of mathematical microaffirmations that instructors can use:

1. Believing in students' mathematical ability: This includes valuing all contributions, even incorrect answers, acknowledging the difficulty of tasks, encouraging students to consider mathematics as a major, inviting participation in research, and listening attentively to questions and concerns.
2. Engaging in relational practices: These practices involve building a supportive classroom community, learning and using students' names, showing genuine interest in students, affirming their emotions, especially when they feel overwhelmed, and validating their struggles while reinforcing capabilities.
3. Recognizing Metacognitive Practices: Instructors can reinforce productive learning behaviors such as participating in study groups, attending office hours, and using positive self-talk.

Effective implementation of these mathematical microaffirmations requires conscious effort, thoughtfulness, and care. Instructors must cultivate a classroom culture where students feel respected, seen, and capable of success. Importantly, mathematical microaffirmations are more powerful when directed at individual students rather than announced as a general encouragement to the entire class. They are meaningful when they come from individuals in positions of authority, such as instructors. However, these practices must be applied equitably and thoughtfully to avoid being perceived as microaggressions or reinforcing patterns based on race, gender, or perceived ability. When used with care, mathematical microaffirmations can serve as powerful tools to foster students' sense of belonging in mathematics classrooms (Cawley & Wilson, 2023).

Belonging and Microaggressions

Sue et al. (2007, 2008) defined microaggressions as brief, everyday exchanges that send denigrating messages to certain individuals that they do not belong because of their group membership, which can have a significant cumulative impact on those at whom they are directed. The concept of microaggressions was first introduced by Pierce (1970) to describe how African Americans experience everyday racism. Microaggressions are subtle insults (verbal, nonverbal, and/or visual), and those who perpetuate them may be unaware of their harmful nature (Wingrove-Hauland & McLeod, 2021). These exchanges marginalize individuals based on race, gender, sexual orientation, political beliefs, disability status, job title, or other identities (Ellis et al., 2019). According to McGee (2018), microaggressions are particularly widespread in STEM departments. The impact of microaggressions can be severe, leading to low self-esteem, anxiety and depression (Boyce-Rosen & Mecadon-Mann, 2023). Extant research demonstrates that microaggressions communicate to racially minoritized students that they do not belong on campus (Ellis et al. 2019), which may undermine their sense of belonging.

Mathematical Microaggressions

Extending this concept of microaggressions to mathematics education, Su (2015) introduced the term “mathematical microaggressions” to describe the subtle ways in which authority figures in mathematics, such as instructors, use language, behavior, and assumptions to signal that certain students do not belong in mathematics. Unlike general microaggressions, which are often based on demographic identities, mathematical microaggressions specifically undermine students’ mathematical identity and confidence. Common dismissive phrases are “It is obvious,” “You either get it, or you don’t,” or “You should have learned this before.” It can also include behaviors such as ignoring student questions, moving too quickly through material, or skipping key steps in explanations.

Cawley and colleagues, (2023) identified three types of mathematical microaggressions: microslights (unintentional comments), microinsults (intentional remarks that harm students’ mathematical ability), and environmental microaggressions (structural elements that exclude students without direct interaction). In their study at a Hispanic-serving institution, 70% of students reported experiencing mathematical microaggressions, with female students disproportionately affected (78%) compared to male students (64%). While existing research has shown that racial or gender-based microaggressions can decrease students’ sense of belonging, the specific effects of mathematical microaggressions on students’ sense of belonging within mathematics classrooms remain underexplored.

Belonging and Mathematics Self-Efficacy

Definition and Theoretical Foundations of Mathematics Self-efficacy

Self-efficacy is a core construct in Bandura’s social cognitive theory and refers to an individual’s belief in their capacity to successfully execute behaviors necessary to produce specific outcomes (Bandura, 1977). It functions as a cognitive mechanism that mediates behavioral change across various contexts. Bandura identifies four primary sources of self-efficacy: mastery experiences, vicarious experience, verbal persuasion, and physiological/affective states. Importantly, Bandura distinguishes self-efficacy from outcome expectations, which is the belief that a particular behavior will lead to certain results.

In the context of mathematics education, mathematics self-efficacy is defined as “a situational specific assessment of an individual’s confidence in his or her ability to successfully accomplish a particular task or problem” (Hackett & Betz, 1989, p. 262). It reflects students’ self-perceived competence in performing specific mathematical tasks and is closely linked to their engagement and persistence. Notably, a student may understand that certain behaviors lead to success in mathematics but still lack confidence in their ability to perform those behaviors effectively. Mathematics self-efficacy has been shown to be a stronger predictor of academic performance than prior knowledge, intelligence test scores, or self-esteem (Zakariya, 2022).

Four Sources of Mathematics Self-Efficacy

Bandura’s four sources of self-efficacy have been widely applied in mathematics education research:

1. Mastery Experiences

   This is the most influential source of self-efficacy. It involves students’ interpretations of their past successes or failures in mathematics. Positive experiences and successfully completing challenging tasks enhance self-efficacy while repeated failures diminish it. Zakariya (2022) emphasized that students’ subjective interpretations of their performance are more impactful than objective outcomes.

Mastery experience is consistently found to be the strongest predictor of mathematics self-efficacy (Usher & Pajares, 2009).

2. Verbal or Social Persuasion

   This is the second most influential source after mastery experiences. This source includes encouragement, feedback, and evaluations from teachers, parents, or peers. Positive reinforcement can bolster self-efficacy, and negative feedback may undermine it. Research suggests that negative feedback may have a stronger effect in weakening self-efficacy compared to the strengthening effect of positive feedback (Zakariya, 2022).

3. Physiological and Affective States

   This source pertains to the emotional and physical responses students experience during mathematical tasks. Feelings of calmness and emotional stability can enhance self-efficacy. Students who experience negative feelings when attending mathematics classes may believe that this is due to their lack of ability in mathematics (Usher & Pajares, 2009).

4. Vicarious Experiences

   This involves observing peers succeed in mathematics tasks. When students see others like themselves succeed, their own confidence may increase. Warwick (2008) noted that favorable peer comparisons can strengthen mathematics self-efficacy. However, among the four sources, vicarious experience tends to have the least influence (Zakariya, 2022).

The Relationships Between Belonging and Mathematics Self-efficacy

Multiple studies have documented the connection between students' sense of belonging and their mathematics self-efficacy (Freeman et al., 2007; Graham et al., 2023; Wilson et al., 2015; Yavorsky, 2017; Zumbrunn et al., 2014). Zumbrunn et al. (2014) proposed a directional relationship, suggesting that belonging is a prerequisite for developing self-efficacy, stating that "higher self-efficacy may be less likely unless aspects of the classroom context first facilitate belonging" (p. 666).

Although closely related, belonging and mathematics self-efficacy function as distinct constructs. Wilson et al. (2015) emphasized that "belonging is not simply reducible to feelings of self-efficacy" (p. 765), highlighting their independent contributions to student outcomes. Graham et al. (2023) found that belonging was a stronger predictor of students' behavioral responses to active learning than self-efficacy. Deshler et al. (2019) argued that even for students with high self-efficacy benefit from emotional support in academic settings. These authors suggest that instructors can foster both belonging and self-efficacy through practices that encourage participation, demonstrate enthusiasm, provide opportunities for mastery experiences and offer constructive verbal persuasion.

Intersectionality

History of Intersectionality

Although intersectionality's originals are difficult to point out, the earliest forms dates to minoritized women's activities in the 19th's century (Esposito & Evans-Winters, 2022). In the 1960s, Black women engaged with the practices of civil rights but were subordinated to men within these movements. During the 1970s, Black women activists confronted that their needs concerning employment, education, and healthcare were not addressed by antiracist social movements, feminism, or movements focused on worker's rights. Because Black women were Black and female workers, single-focus lenses on social inequity could not address the complex social dilemma they faced, and their unique issues remained ignored within each movement (Collins and Bilge, 2020).

Then in the 1980s, the idea of intersectionality began to be included in scholarship, but it was unnamed, and instead the phrase, "race, class, and gender" was used. The term "intersectionality" was introduced in the late 1980s to expose how single axis thinking undermines women of color and their struggles for social justice (Cho et al., 2013). Crenshaw (1989, 1991) is credited with introducing the term "intersectionality", as an extension from critical race feminism and legal scholarship, to explore how Black women experience double discrimination on the basis of race and sex. Crenshaw (1991) explained that women of color's racialized experiences is not the same as those experienced by men of color; similarly, gendered experiences are not representative of those experienced by White women.

Crenshaw focused on the intersections of race and gender to highlight the need to account for multiple identities. She claimed that the experiences of women of color are important to understanding and improving important social issues, but these women remain a devalued group in academia as well as within broader US society. She argued that the needs of women of color cannot be met by looking at one category of analysis because their multiple identities (e.g., race, ethnicity, immigrant status, and class) position them differently since multiple systems of power impact their lives. Therefore, a more comprehensive analysis of social problems is required to produce more effective social actions. Crenshaw (1989) wrote, "Because the intersectional experience is greater than the sum of racism and sexism, any analysis that does not take intersectionality into account cannot sufficiently address the particular manner in which Black women are subordinated" (p. 140). Berry and Cook (2018) claimed that race and gender are social constructs that have been used to create discrimination throughout the world. Crenshaw (1991) explained, "is not to say that the category has no significance in our world. On the contrary, a large and continuing project for subordinated people … is thinking about the way power has closeted around certain categories and is exercised against others" (p. 1296-1297).

In the U.S., Black women were part of broader social movements in which Latinas, Indigenous women, and Asian American women (who subsequently became redefined as women of color) engaged in social projects aimed to dismantle multiple social inequalities in their everyday life experiences. Female scholars of color have used the idea of intersectionality to critique the exclusion of the experiences, needs, and perspectives from both White, Eurocentric, middle class, and male dominated models to center the lives of women of color (Dill, 2009). Dill and Zambrana (2009) explained that inequality and oppression are deeply embedded into American life and result in large disparities in measure of income, wealth, education, housing, occupation, and social benefits and occur in patterns along major social divisions as race, gender, class sexuality, nationality, and physical ability. By the early 2000s, intersectionality has gained more acceptance as a field of study and has been used to investigate social problems such as poverty, poor education, substandard healthcare, inadequate housing, and violence (Collins, 2009).

Definition of Intersectionality

Intersectionality is related to one of the core elements of Strayhorn's (2019) theoretical model of belonging: (5) social identities intersect and affect students' sense of belonging, and students experience belonging in different ways. However, there are few studies that use an intersectional approach to study the sense of belonging on racially diverse students' experiences in STEM fields. There are various definitions of intersectionality. Dill and Zambrana (2009) described intersectionality as an “innovative and emerging field of study that provides a critical analytic lens to interrogate racial, ethnic, class, physical ability, age, sexuality, and gender disparities and to context existing ways of looking at these structures of inequality” (p. 1). McCall (2005) defined intersectionality as the “relationships among multiple social dimensions and modalities of social relations and subject formations” (p. 1771). Shields (2008) stated that intersectionality varies by research context but it is the “social identities which serve as organizing features of social relations, mutually constitute, reinforce, and naturalize one another” (p. 302).

For my study, I will be using Collins and Bilge’s (2020) working definition of intersectionality: Intersectionality investigates how intersecting power relations influence social relations across diverse societies as well as individual experiences in everyday life. As an analytic tool, intersectionality views categories of race, class, gender, sexuality, class, nation, ability, ethnicity, and age – among others – as interrelated and mutually shaping one another. Intersectionality is a way of understanding and explaining complexity in the world, in people, and in human experiences (p. 2).

Students’ experiences of belonging are influenced by the intersection of their social identities which may require different strategies for encouraging students’ belonging in STEM fields (Strayhorn, 2019). Using belonging as a lens can involve analyzing what it means to live with diverse social identities and struggle with marginalization (Chung & Rendon, 2018). Belonging studies should incorporate intersectionality, which as a framework considers how the combination of different identities such as race, gender, and class operate in different contexts. However, intersectionality is not about possessing multiple identities; rather, it is the ways in which intersecting identities have been marginalized in the U.S (Berry et al., 2018). Rendon et al. (2000) stated, "… much more work needs to be done to uncover race, class, and gender issues (among others) that impact retention for diverse students in diverse institutions" (p. 151). With higher education becoming more diverse, intersectionality is a powerful explanatory framework to think differently about the ways in which we meet the needs of minoritized students.

Chung & Rendon (2018) explained that intersectionality is what happens when multiple, intersecting social identities of an individual (e.g., race, ethnicity, ancestry, gender, class, sexuality, geography, age, disability, immigration status, religion, political affiliation, and worldview) interact with overlapping systems of power and privilege in society. From an intersectional perspective, social injustices are never the result of a single factor. Social, political, and economic structures privilege certain social identities at the expense of others. An intersectional analysis of social issues, including educational achievement, can assist in developing policies to remove obstacles, create opportunities, and affirm equity. As a theory, Chung and Rendon emphasized that intersectionality could help us understand the social issues and the lived experiences of feeling what it means to be "the other," and to struggle with marginalization. Therefore, I will use intersectionality to guide my study in understanding the experiences and sense of belonging of female minoritized students, who sit at the intersection of race and gender, as "double minorities" (Delgado & Stefancic, 2012).

Core Ideas Within Intersectionality

Intersectionality work embraces some combination of the following core ideas (Collins & Bilge, 2020; Collins, 2015; Dill & Zambrana, 2009):

(1) Social inequality is rarely caused by a single factor and intersectionality moves beyond viewing social inequality through race-only or gender-only lenses;

(2) Intersectionality attends to issues of how power operates to shape privilege and oppression, as well as relations between individual identities and larger structures of inequality in different historical, cultural, and structural contexts. Inequalities derived from race, ethnicity, class, gender, and their intersections place specific groups in a privileged position with respect to other groups, and offer individuals benefits solely on group membership;

(3) Social context is important when examining intersecting power relations. Because social formations of complex social inequalities are historically contingent and cross-culturally specific, social experiences vary across time and space. Individual identity exists within and socially defined statuses that may be more salient in specific moments or situations;

(4) Relationality informs all aspects of intersectionality as it embraces a both/and framework that shifts away from seeing categories as oppositional to examining their interconnections. Multiple identities are understood in relation to particular and changing social and political contexts. Race, class, gender, sexuality, age, ability, nation, ethnicity, and similar categories of analysis are best understood in relational terms rather than in isolation from one another. For example, gender-only examinations in introductory mathematics classrooms may not be sufficient to explain differences in sense of belonging;

(5) Intersectionality is connected to a commitment to *social justice* by examining some aspect of social inequality;

(6) Intersectionality is a lens that supports the aim to understand the complexities of lived experiences and therefore using intersectionality as an analytic tool is difficult. For example, intersections of race and gender can identify the need for class analysis or other categories of analysis. The framework acknowledges the significant diversity within groups, as identity is

complicated by differences in national origin, citizenship, class, physical ability, sexuality, religion, gender, race, and ethnicity;

(7) The experiences of marginalized groups are in the center of historical and current intersectional theory and practice, with a focus on how race and ethnicity intersect with other categories of identity such as gender or economic class. This emphasis on lived experiences of individuals highlights the voices of those previously excluded, such as the stories of Black, Latina, Asian American, and Native American Indian women.

Intersectionality and Higher Education

Intersectionality has been widely used beyond law, its field of origin, and has made contributions to other fields such as criminal justice, public health, history, sociology, psychology, ethnic studies, leadership studies, philosophy, queer studies, feminist studies, and international studies. Traditionally, intersectionality has been less common in higher education research, which has typically been restricted to an examination of singular identities, and did not to consider how the intersecting power relations of race, ethnicity, class and gender affect students' identity, perspectives, and experiences shaped by systems of oppression and privilege (Charleston et al., 2014). Singular explanations of complex social issues may not offer sufficient insight into the structural factors that produce discriminatory practices in college, and may even lead to deficit narratives (Strayhorn, 2013). Explanations of academic outcomes often rely on individual or cultural factors, failing to address issue of equity and the intersections of race, ethnicity, class, and power relations (Zambrana & Dill, 2009).

Colleges and universities have become important contexts for scholarship for intersectionality to explore how race, ethnicity, SES, gender, and other factors influence a student's access to opportunities, and experiences in higher education. Higher education institutions are facing the challenge of building more inclusive communities as they now enroll more college students who historically faced discriminatory barriers to enrollment due to their race, ethnicity, gender, etc. Nevertheless, social divisions constructed by power relations of class, race, gender, ethnicity, sexual orientation, and ability are still very much embedded in higher education (Collins & Bilge, 2020).

Intersectionality and STEM Education

Johnson (2011) emphasized that minoritized female students in STEM face oppression and discrimination based on their race, ethnicity, and gender. Moreover, minoritized female students are the least recognized, and the most invisible and marginalized underrepresented groups in STEM education. Therefore, there is a need for frameworks that address minoritized female students in STEM as a stand-alone population (Ong et al., 2011). Intersectionality can meet this need, to capture racialized and gendered forms of STEM experiences that demote sense of belonging, and to disrupt deficit discourses about female minoritized students. Ireland and colleagues (2018) remarked that intersectionality allows researchers to critically explore why and how STEM female minoritized students have distinctive experiences related to their social identities, psychological processes, and educational outcomes. However, very few studies have studied sense of belonging with an intersectional approach (Strayhorn, 2019).

The metaphor of "pipelines" is often used to refer to the underrepresentation of women as well as Black and Latinx students in STEM. The problem is described as cracks where female minoritized students leak out of STEM majors. However, Collins & Blige (2020) argued that framing issues of educational equity as separate pipelines for women and for students of color is limiting and shortsighted. Because female students of color are considered a subcategory of gender pipelines, they are perceived to experience "special" problems not representative of the core group of White female students. Black and Latina female students do not fit within either the gender pipelines or the racial/ethnic pipeline (Charleston et al., 2014). A failure to consider the integration of race, class, and gender may lead to an inaccurate and incomplete understanding of what occurs in STEM education. Ong and colleagues (2011) noted that the intersectional identities of minoritized women are important in their development and persistence in STEM. Intersectionality explanations could help attend to barriers that female minoritized women face within the structural organization of institutions, providing a more expansive lens for addressing the complexities of educational equity (Grant & Zwier, 2011).

Intersectionality and Identity

Identity has been an important dimension of intersectionality research as it allows for the exploration of relationships between identity categories and individual differences in larger social systems. An individual's sense of identity can be based simultaneously on their race, ethnicity, class, gender, sexual orientation, religion, and other aspects. Identity is defined as "the social categories in which an individual membership as well as the personal meaning associated with those categories" (Shields, 2008, p. 301). Individual identities are fluid and shaped by multiple factors, but they are experienced as stable, giving the self a sense of continuity across time and social context. However, intersectionality is not a theory of individual identity (Collins & Bilge, 2020), it is about the ways in which the multiple identities have been socially constructed as marginalized in U.S. society (Berry & Cook, 2018). Scholars engaged in intersectional work should consider the complexities of identity and the ways in which individual and group identities and interact with one another (Dill and Zambrana, 2009).

An intersectional perspective requires that identity categories be examined in relation to one another at the individual, interpersonal, and structural level and situates identity within larger structures of power and privilege in sociocultural and historical contexts. Identities are socially constructed and negotiated, and we embody all of our social identities and experience the world based on interconnected systems such as race, class, gender, etc., in every social situation (Wijeyesinghe & Jones, 2014). The interaction of an individual's multiple marginalized and privileged identities creates a unique experience (Museus & Griffin, 2011). When all their identities are considered, Shields (2008) explained that each individual is in a position of both social privilege and social marginality.

Systems of power and privilege strongly shape personal and group experience. Intersectionality attends to identity by linking individual experience to a person's membership in social groups within larger, interlocking systems of power, advantage, and access. Identity at the individual level incorporates multiple social systems that influence one another and connect privilege and oppression in more complex ways. It is not possible to understand the complex interplay of power, privilege, and social structures if we view forms of oppression as singular and separate units (e.g., racism, ableism, sexism, classism) or if we focus only on forms of oppression that feels most salient to an individual in a specific setting (Wijeyesinghe & Jones, 2014).

The identity dimension that receives the most attention in higher education research is race but racial categorization on surveys may not get at the complexity of students' racial identities and realities. Capturing students' identities is a complicated endeavor that is dependent on context. In higher education, we use categories to compare groups with little attention to how we are capturing this information or knowing whether this information accurately describes students and how they conceptualize their own identity (Harper, 2011). Identity and intersectionality can be used to enhance our understanding of the experiences of students.

Wijeyesinghe & Jones (2014) explained, “Intersectionality is a power tool of understanding the experience of identity, the complex and mutually constituting nature of social identities, the relationships between identity and larger social systems, … lived experience of individuals within the context of their social groups, oppression and inequality, and interventions for social change” (p. 17).

Challenges of Intersectionality

Because intersectionality is still evolving as a theoretical perspective, critics argue that it lacks a precise and diverse methodological approach (Collins, 2015). Another criticism is that intersectionality overemphasizes personal identity and gives the category too much explanatory power to understand social phenomena. A related criticism is that intersectionality focuses on essentialist conceptions of identity, and views individuals as holding fixed identities across contexts (Jones & Wijeyensinghe, 2011). Questions have been raised about the utility and limitation of the road intersection metaphor and the additive versus interactive identities of race, gender, class, sexuality, nation, etc. But much of intersectional research supports the perspective that individuals have varying combinations of multiple identities across social contexts. Yet, identity remains a debated category among intersectional scholars (Collins & Bilge, 2020).

Others have expressed reservations about using intersectionality to address other marginalized communities due to its historical focus on American Black women. Some critics of intersectionality say the framework fails to give all intersectional subjects attention and ask whether people with privileged identities are outside of the framework. (Cho et al., 2013). It is true that intersectionality as a construct has traditionally focused on the experiences of groups holding multiple disadvantaged statuses. However, some individuals embody both privileged and oppressed identities (e.g., middle-class Black people, White women); therefore, this framework can also inform how privileged groups are understood (Cole, 2009). Wijeyesinghe & Jones (2014) remarked, “The question of whether intersectionality applies to everyone reinforces a point made earlier, that intersectionality is not simply about multiple identities, which we all have, but multiple identities connected to groups and structure of power, thus, paving the way for a both/and approach. Considering the application and relevance of intersectionality to people and groups who receive social advantages begins to draw some boundaries related to privileged and oppressed identities” (p. 16). They added that intersectionality explores ways in which some people within social groups receive benefit while others are disproportionately constrained by certain social-structural contexts. The purpose of intersectionality is not simply about locating individuals within boundaries, it is more about understanding the experiences of others and the social structures that perpetuate privilege and oppression. Intersectionality as a critical analytic lens can advance equity and inclusion for all, validate diverse social identities, and result in better informed policies and interventions to address social issues (Chung & Rendon, 2018).

I am drawn to the transformative aims of intersectionality, to improve the experiences for minoritized students in education. Intersectionality work originated from an effort to improve society, by understanding and explaining the lives and experiences of marginalized people (Dill and Zambrana, 2009). As a framework, it is connected to social justice, and as a tool, it can be used to empower communities and the people in it. Wijeyesinghe and Jones (2013) wrote that we are just beginning to understand how intersectionality can be used to dismantle inequality and social justice within the classroom, higher education, and larger society. In an interview, Crenshaw (2018) encouraged educators and researchers to use intersectionality and “commit themselves to understanding that as a way of intervening and providing equal educational opportunity for all students regardless of their identities.” In order do so, Strayhorn (2013) suggested that researchers first identify and examine the problem by uncovering relations of social identities, power, and their intersections to address the problems that minoritized groups encounter.

Authorizing Student Perspectives

A central idea of intersectionality is to center the experiences and voices of individuals whose identities exist at the margins (Charleston et al., 2014). Grant & Zwier (2011) claimed that an intersectional perspective can better support teaching and learning by centering students' voice and experiences. However, student perspectives have often been excluded from the education discourse (Cook-Sather, 2006). Consequently, I will draw on Cook-Sather's (2002) notion of *authorizing student perspectives* to understand the experiences and sense of belonging of minoritized female students in gateway mathematics classrooms.

Cook-Sather asserted that education researchers must include students' perspectives because they hold a unique understanding of what occurs in classrooms, as they experience first-hand the existing educational policies in practice on a daily basis. Therefore, educators should ask students directly what they want and need, and must repeatedly ask these questions to see the world from their perspectives. Cook-Sather (2002) wrote, "Those of us currently invested with authority must confront the power dynamics inside and outside our classrooms…and count students among those who have the knowledge and position to shape what counts as education" (p. 3). Similar to intersectionality, the aim of authorizing student perspectives is to reveal what is happening in the classroom and the potential for change.

Cook-Sather (2006) explored the history of the term "student voice," in educational research literature. In the early 1990s, a number of educators remarked that students' voices, experiences, and perspectives were excluded from dialogue about learning, teaching, and schooling and called for the need to challenge the idea of students as silent, passive recipients of what others define as education. For example, Kozol (1991) noted that children's voices were missing from education, despite the fact that "children are more … perceptive than the grownups about the day-to-day realities of life in school" (p. 6).

Having a voice is having presence, power, and agency, having the opportunity to speak one's mind, be heard, and perhaps to have an influence on outcomes. Voice allows individuals to name their experience and participate in decisions that affect their lives. Therefore, "student voice," according to Cook-Sather (2006), is about "having the power to influence analyses of, decisions about, and practices in schools" (p. 364). Relatedly, to authorize student perspectives means to acknowledge students as having knowledge and invaluable viewpoints, and the potential to directly improve current educational practice. Excluding their perspectives from our discourse on education leads to an incomplete understanding of life in classrooms and institutions. Authorizing students is not simply including students in existing conversations; rather it is about ensuring that there are valued spaces in which students can speak, so that we can listen and act in response to their stories. However, authorizing student perspectives may be challenging because educators and institutions have not been inclined to seek and attend to students' voices (Cook-Sather, 2002).

However, a concern with student voice or authorizing student perspectives work, as with intersectionality, is the possibility of oversimplifying students' narratives and insights as a single entity, essentializing students' experiences. Moreover, questions have risen about which voices are elicited and attended to in research, as under-represented students' perspectives have been excluded. At the post-secondary level, there have been increasing efforts to include under-represented students in classroom-based research. Higher education has lagged behind K-12 contexts in formal integration of student voice in educational research, but such efforts have expanded in recent years. Students' perspectives, particularly of those students traditionally underrepresented in and underserved by higher education, have the potential to make important contributions to discussions on how to best support their success (Cook-Sather, 2018).

Efforts to Authorize Students' Perspectives

According to Cook-Sather (2002), constructivist approaches contribute to the notion of authorizing student perspectives by positioning students to create and assess their own understanding, which then allow teachers to improve their practice by listening closely to what students say about their learning within the classroom. Critical pedagogies also allow students to be active participants in their own knowledge construction, by building upon themes that are relevant to students' own lives. These pedagogies can embody multicultural and anti-racist practices in education.

Shultz & Cook-Sather (2002)'s *In Our Own Words: Students' Perspectives on School* is an example of committing to directly asking students about their perceptions, feelings, and insights about middle and high school. Cook-Sather has also maintained a project in an undergraduate teacher preparation course to elicit student perspectives. As a preservice teacher in the program many years ago, I participated in this program via weekly email exchange and in-person interviews with students from local public high schools. It was a reflective and rewarding experience, although at first, I was resistant to acknowledge that I had something to learn about teaching and learning from high school students. Sometimes, I became frustrated when students expressed something I did not agree with, and I think that came from a place believing that I knew more about "education" than they did. Cook-Sather (2002) expressed that her goal for these forums was to position high school students as authorities and to challenge the preservice teachers to develop beliefs and practices that are informed by what high school students identify as critical issues in teaching and learning.

Power and Authorizing Student Perspectives

Cook-Sather (2002) cautioned that we must be wary of unreflectively privileging student voices without considering the intersection of identity language, context, and power that inform all pedagogical relationships. Power dynamics are complicated in classrooms and we must constantly examine our own assumptions and motives when questioning power structures that support them. Participation and power are important constructs in the analyses and understanding of students' classroom experiences and differential outcomes because power relations exist in all interactions in education spaces (Aguirre et al., 2017). Most power relationships do not allow for listening openly and critically to students, because to really listen means to have to respond. Learning from student perspectives requires major shifts in ways of thinking, believing, and feeling about knowledge, language, power, and self, for teachers, students, and researchers. However, educators must be willing to attend to students' perspectives and act on what they express by taking small steps toward changing oppressive practices even if it feels unattainable. Cook-Sather (2002) emphasized that authorizing student perspectives "is about including students to change the terms and the outcomes of the conversations about educational policy and practice" (p. 12). We must move beyond the idea that we, educators, know what education is and should be and have all the answers. Instead, we should acknowledge that we do not know what it means to be a student in the current world and recognize students as having essential knowledge for the development of positive educational practices. By listening closely to what students have to say about their learning, educators can improve their practice and counter discriminatory and exclusionary practices in STEM education, to promote students' sense of belonging in this space.

Literature Review

This section consists of five subsections: terminology, existence of gender and racial disparities in undergraduate STEM education, explanation of these gaps, contexts that foster successful outcomes for minoritized and female students, extant research on sense of belonging and its importance. The first section defines the terms, minoritized and Latinx, to clarify the meaning and how these terms are used in the higher education literature. The second section details the underrepresentation of Black, Latinx, and female students in STEM while the third section explains why these gaps exist. The fourth section presents successful cases of how Minority Serving Institutions and women's colleges have provided structures and environments where racially minoritized students and women can be successful. The last section outlines research related to students' sense of belonging. The chapter concludes with a summary of why we need to explore sense of belonging of minoritized female students.

Descriptions of Terms: Minoritized and Latinx

Minoritized as a Term

The term *minoritized* is sometimes used to refer to students who are underrepresented in STEM fields, most commonly, Black and/or Latinx students (Burdman et al., 2021). The original definition of minority was based on numerical size and is still commonly used to describe minoritized groups. To be "minoritized" is to be treated as a member of a group that is suppressed by and disadvantaged relative to the dominant social group in a given context. Being minoritized is not about numbers, but about power and equity. For example, women are not a numerical minority within the U.S. but have been minoritized throughout history and are still minoritized today. Therefore, being minoritized is fluid and can change depending on the context. Labeling someone a member of a minority group or an underrepresented minority inaccurately represents that person's minority status, as an attribute of that person, because majority people do not have that characteristic. However, referring to someone as having been 'minoritized' makes it clear that it is something that is done to them, rather than being a characteristic of those who are minoritized (Wingrove-Haugland & McLeod, 2021).

Being minoritized is a necessary but not sufficient condition for being marginalized or oppressed. Being minoritized involves being prevented from gaining equal power and socioeconomic equality. "Minoritized" does not refer to a group of people, but rather it is about how these groups are treated by members of a dominant group in society. The phrase "under-represented minority" seems to imply that being minoritized is only problematic if one is 'under-represented,' as if racism or sexism will simply disappear if minorities are adequately represented. Therefore, 'minoritized' emphasizes the similarities shared by everyone who is minoritized while recognizing that there are also differences among minoritized groups. I use the term "minoritized" because, as Wingrove-Hauland & McLeod (2021) suggested, it is a more productive way to refer to those who have been marginalized.

According to Johnson (2011), minoritized women includes Black, Latina, Native American, Asian Pacific American, and multiracial women. Minoritized women may share the common experience of racial discrimination or oppression, but each group also has unique social, economic, and political histories that contribute to their marginalizing experiences in the U.S. educational system.

Latinx as a Term

The term Hispanic was first adopted by the U.S. government and was implemented in the U.S. Census in 1980 to refer to people who are from countries where the primary language is Spanish. Before the term Hispanic was adopted, the census counted people such as Mexican

Americans as “White.” In contrast, the term Latino was adopted to label individuals who identify people of Central or South America and even those countries that are not Spanish speaking. A key similarity between both terms is that they both refer to a cultural and ethnic group, and not a race (Salinas & Lozano, 2017).

Latinx first appeared in early 2000s as a way to promote inclusivity in language and offering a gender-neutral version of the term to move beyond the masculine-centric ‘Latino’ and the gender inclusive but binary ‘Latin@’. The term Latinx has gained popularity in recent years mostly in higher education scholarship to recognize the intersectionality of sexuality, language, immigration, ethnicity, and culture. Some have criticized the term as originating from U.S. English speakers in academia to describe marginalized populations, ignoring the Spanish language and its gendered form. Salinas and Lozano (2017) argued that the term Latinx has evolved to represent those individuals who do not identify with the gender binary, at various intersections of gender in order to promote an inclusive space for all genders and the intersections. The authors advised researchers to ask individuals how they self-identity to avoid making assumptions regarding their gender identity.

Racial and/or Gender Gaps in STEM Education

Research addressing minoritized and female students has emphasized the existence and persistence of racial and gender gaps in STEM education. Racial, ethnic and gender disparities have been well-documented in STEM degree completion rates. Black, Latinx, and Indigenous individuals earned only 18% of STEM bachelor’s degrees in 2018, and women earned only 36% of STEM bachelor’s degrees in 2017. Some scholars argue that racial and gender achievement gaps are a result of historical, political, and socio-cultural factors as well as access to well-funded schools, highly qualified teachers, and high-level mathematics courses (Barbieri &

Miller-Cotto, 2021; Martin, 2009; McGee, 2020). Various explanations offered for the achievement, participation, and persistence gaps in STEM have included insufficient K-12 preparation for college level STEM courses, weak study skills, low motivation and effort, low socioeconomic background, a lack of social capital and family support, and first-generation status (Strayhorn, 2013; Gasmen et al., 2017; Kuh et al., 2006; Seymour & Hunter, 2019; Malcom & Malcom, 2011; Copur-Gencturk et al., 2019; Treisman, 1992; Casad et al., 2018; Estrada et al., 2019). Others have emphasized student attributes that lead to persistence such as motivation, grit, and mindset (Duckworth & Quinn, 2009; Dweck, 2006; Estrada et al., 2018). Persistence describes continuation in a college course sequence or major and is commonly used in higher education literature (Burdman et al., 2021). While these explanations provide one possible framing to understand the underrepresentation of Black and Latina women, these perspectives attribute these gaps to student traits, which lead to deficit thinking that holds students accountable for the challenges and inequities they face (Davis & Museus, 2019). Later in this section, I will discuss how these perspectives may contribute to maintaining, rather than challenge, the oppressive structures, policies, and practices within STEM educational settings.

Importance of Introductory STEM Courses

It appears that STEM minoritized and female students are getting “stuck” at the STEM introductory course level. For example, undergraduate mathematics classes have a high failure rate and are a major contributor to increased attrition rates. In fact, they are the most significant barrier to degree completion in both STEM and non-STEM fields (Saxe & Braddy, 2015). While precalculus and calculus courses are considered gatekeeper courses for entrance into STEM (Battey et al., 2022), college algebra may be typical first introductory math course at open-access institutions for first-year students intending to major in STEM.

Gateway mathematics courses such as calculus 1 may influence a first-year students' decision to remain in STEM. Bressoud and Rasmussen (2015) discovered, for instance, that students' enjoyment of mathematics, confidence, and belief in their ability to succeed in Calculus 1 dropped by the end of the semester. Even with final grades of As and Bs, twice as many female students decided not to take Calculus 2 because they felt that they did not understand calculus well enough or that their grade was not good enough despite having good grades. Sanabria & Penner (2017) also found that women who intended to major in STEM and fail calculus are significantly less likely to obtain a STEM degree, while no similar findings were found for men. Similarly, Ellis and colleagues' (2016) study showed that female college students were 1.5 times more likely than men to not continue from Calculus 1 to Calculus 2 while controlling for academic preparedness and career intentions. Likewise, women with above-average mathematical preparedness and abilities in Ellis et al.'s study reported higher rates of not understanding the course material well enough and also started and ended the semester with significantly lower mathematical confidence than men. Seymore & Hunter (2019) also found that female students decided to switch from a STEM major after losing confidence in their abilities.

Similar to how Calculus negatively impacts female students, Hatfield and colleagues (2022) pointed to the importance of introductory STEM courses on minoritized students' STEM degree attainment. They used intersecting identity categories, drawing on a dataset from six large, public, research-intensive institutions and found that there is a stronger negative impact of failing an introductory STEM course for female and/or Black, Latinx, and Native American students even after controlling for high school preparation and intent to study STEM. Moreover, they also reported that White male students had the highest likelihood of obtaining a STEM degree (48.4%), while female minoritized students were the least likely (35.3%). Black female students in particular, had the lowest probability (28.2%) of graduating with a STEM degree. The authors suggested that departments, colleges, and universities critically reflect and examine their policies and cultures.

In a multi-institutional study, Seymour and Hunter (2019) found that minoritized STEM students described the following four concerns more often than did their White peers: inadequate high school preparation, difficult transition to college, the competitive, unsupportive STEM culture making it difficult to belong, and discouragement/loss of confidence due to low grades in early years. Minoritized female students in particular were more likely to report that they were poorly prepared in mathematics. Nearly all STEM switchers, both minoritized and White students, reported poor quality teaching, problems with curricular design, and conceptual difficulties with STEM courses. Furthermore, STEM switchers reported losing interest in their major as a result of poor teaching in STEM introductory courses such as calculus more often than STEM persisters.

As these studies indicate, students' first year in STEM programs is important because students often experience self-doubt and discouragement during their first year of college which results in the loss of many female students and racially minoritized students in STEM (Rosenthal et al., 2011). Moreover, STEM introductory courses serve as the primary point of contact for students to their campus, opportunities for interactions, and meaningful relationships with their peers and instructors. In these STEM courses, minoritized female students, in particular, report feeling a low sense of belonging due to a lack racial and/or gender diversity (Johnson, 2011; Charleston et al., 2014).

Explanations of Why Racial and Gender Disparities Exist in STEM

Deficit Perspectives and Narratives

Lubienski and Gutierrez (2008) argued that much of the research addressing achievement gaps and underrepresentation of minoritized and female students only retells us what we already know, reinforces deficit perspectives, and does not offer a positive impact on improving student outcomes. Deficit narratives contribute to racial inequities by overfocusing on achievement gaps and then attributing these gaps to deficiencies within minoritized students, their families, their backgrounds, their cultures, or their membership in racial and gender categories while ignoring the structural systems that influence disparities in educational outcomes (Aguirre et al., 2017; DiME, 2007; Yosso, 2005; Davis & Museus, 2019). In the field of mathematics education research, deficit narratives perpetuate inequities by normalizing the low achievement of Black and Latinx students (Aguirre et al., 2017; Gutierrez, 2008) and positioning them at the bottom of the mathematics hierarchy (Gutierrez, 2013). Furthermore, the notion of meritocracy and fixed intelligence prevalent in STEM education disregards students' racial and gendered identities (McGee & Martin, 2011).

Deficit perspectives tend to focus on what students are missing and are concerned with changing students to become more like the majority. Higher education efforts attempting to mold students so that they better navigate the existing system (with interventions such as bridge programs, undergraduate research experiences and developmental courses) have not been successful in reducing attrition among minoritized students (Hatfield et al., 2022). Educators and researchers may incorrectly assume that existing institutional support structures are accessible and motivated students will take advantage of them (Bensimon, 2007). Disparities in educational outcomes must be addressed, however, as an issue of institutional practices or pedagogical approaches, rather than being attributed to student deficiencies. Transformative practice puts the responsibility of change on institutions and faculty rather than on students who hold relatively little power in the educational environment (Johnson, 2012).

Persistent unequal educational outcomes in higher education can be attributed, in part, to how faculty perceive and interact with their students. Instructors may be unconsciously contributing to inequity through their pedagogical practices, assumptions about how students learn, and interactions with students based on students' backgrounds. Faculty who hold deficit perspectives, may be cognizant of the diversity of their student population and disparities in education, but they may also place the blame of failure on students for lack of effort or academic preparation, without considering institutional or individual practices (Bensimon, 2005). Moreover, Canning and colleagues (2019) found that racial achievement gaps in courses taught by more fixed mindset faculty were twice as large those in courses taught by more growth mindset faculty. Their findings suggest that faculty perspectives of students and mindset beliefs have important implications for the classroom experiences and achievement of minoritized students in STEM.

In order to foster more inclusive STEM environments, STEM faculty and higher education institutions must strive to become more equitable and inclusive by recognizing, examining, evaluating, and addressing how they participate in biased practices that create racialized and gendered climates which marginalize Black, Latinx and female students (McGee, 2020; Copur-Gencturk et al., 2019; Winkle-Wagner 2015; Charleston et al., 2014; Malcom & Malcom, 2011; Kuh et al., 2006). Extant research documents both the barriers that minoritized or female students face, and the ways they persist despite these challenges (Estrada et al., 2018). Spitzer & Aronson's (2015) review of literature showed that several studies focused on reducing achievement gaps, not by addressing structural barriers, but through psychological interventions that help students manage threats to their identity in order to overcome obstacles.

Minoritized students have been conditioned to believe that they must be resilient when they encounter institutional and structural barriers. They may therefore associate their negative academic experiences and outcomes as their own fault or weakness (McGee, 2020). For example, in a study of high achieving Black physics students, students perceived that race was a factor in how they were treated but did not always blame it on race. Instead, they considered the professor’s personality or even their own sensitivity as contributing factors to their differential treatment inside and outside the classroom (Fries-Britt et al., 2013). Furthermore, Seymour and Hunter (2019) discovered that minoritized students tended to blame themselves rather than instructors or institutions for their difficulties compared to their White peers. Similarly, female students attributed failure in mathematics to their low ability more often than male students (Ryckman & Peckham, 1987).

Due to these deficit narratives, negative racial and gender climates in STEM classrooms discourage STEM persistence especially for minoritized males and female students of all races and ethnicities (Seymour & Hunter, 2019). Estrada and colleagues (2018) explained that minoritized students are not consistently or equally receiving messages that affirm social inclusion and community acceptance in STEM contexts. Emphasizing a feeling of community, or sense of belonging takes an anti-deficit, strengths-based perspective to understanding our students, improving our programs, and enhancing our practices and policies to increase student success (Strayhorn, 2019).

Racialized and Gendered Experience in STEM

Although numerous studies now consider race and ethnicity, less focus is on the racialized experiences of minoritized students, even on campuses that are considered minority-serving institutions (Bensimon, 2007). Scholars have started to investigate disparities in STEM education as an issue of gendered and/or racialized experience in STEM classrooms and departments (Borum & Walker, 2012; McGee & Martin, 2011; Leyva, 2017; Hottinger, 2016). Research indicates that female and minoritized students manage messages of belonging and encounter negative experiences in STEM fields more often than White male students (Johnson, 2011; Battey et al., 2022). Black students in particular, report experiencing more incidents of differential treatment and racial microaggressions from faculty than students from all other racial/ethnic groups (Suarez-Balcazar et al., 2003; McGee & Martin, 2011). For example, Black male and female students in Solorzano et al.'s (2000) qualitative study reported feeling invisible or isolated within the classroom setting and encountering microaggressions in faculty-student interactions, which negatively influenced their sense of belonging. However, Black students found strategies to resist stereotypes in their academic achievement, partly through relationships with peers and faculty (Fries-Britt & Griffin, 2007) and shared that it was important having other Black students in their classes to provide support against stereotype threat (Solorzano et al., 2000).

McGee (2018) described the role of race-based stereotypes in shaping the experiences of high-achieving Black and Asian STEM students, and argued that both racial groups endure emotional distress, although the two groups differ in how they are stereotyped. In their study both racial groups reacted to racial stereotypes in ways that were harmful to their mental and physical health. Black students felt that they were not expected to achieve at the same level as White and Asian students in upper-level STEM courses. Therefore, Black STEM students worked relentlessly to prove themselves capable and belonging in rigorous STEM classes and programs. On the other hand, the idealization of Asian students as innately capable in STEM fields inflated their own and other's expectations. Asian students felt that their life choices were narrowed when discouraged by others for wanting to change their major to a non-STEM field. Interestingly, both Asian and Black students shared that they felt pressured to work twice as hard as White students.

Scholars have also explored how racialized and gendered experiences in undergraduate mathematics courses influence student persistence (Borum & Walker, 2012; Ellington & Frederick, 2010; Leyva, 2016; Oppland-Cordell, 2014; Leyva et al., 2021a). For example, Leyva et al. (2021b) explored the racialized and gendered experiences of 18 Black and Latinx students and found that calculus served as a weed-out course from students pursuing STEM majors. In another study, Leyva et al. (2020) reported that students across different race and gender groups shared their experiences of racial or gender stereotyping that created differential opportunities for participation and support. Students pointed to issues of underrepresentation of minoritized students in introductory mathematics classrooms and receiving negative messages about who belongs in STEM fields. Even high-achieving Black mathematics and engineering students in McGee and Martin's (2011) reported experiencing racial microaggressions and stereotypes but responded through stereotype management to see themselves belonging to their discipline. Similarly, Esmond et al. (2009) found that minoritized students and female students have racialized and gendered experiences during group work at a diverse urban high school mathematics classroom. White male students often dominated group discussions and students recognized that achievement and participation are related to their social identities.

Research on Minoritized Female Students' Experience in STEM

The term "double bind" was used by Malcom et al. (1976) to describe the oppressive and discriminatory experiences of minoritized women in STEM, based on their race/ethnicity and gender. Much of the research on minoritized students or female students do not focus on racialized and gendered experiences of female minoritized students. However, Johnson (2011) argued that when studying minoritized students in STEM, gender differences should be analyzed and discussed to gain multiple perspectives on the STEM environment to inform institutional policy and practice.

Recently, more scholars have begun to explore the experiences of female minoritized students that may contribute to disparities in STEM. Female minoritized students report challenges of juggling student and family responsibilities (Johnson, 2011). In STEM environments, minoritized women experience stereotype threat, negative and unsupportive K-12 classroom experiences, feelings of isolation, low expectations from faculty, and microaggressions (Alfred et al., 2019; Ong et al., 2016, 2018; Winkle-Wagner, 2015; Esmond et al., 2009; Booker, 2016; Johnson, 2011). This body of research has documented the ways in which Black and Latina women feel the need to be resilient by engaging in stereotype management and relying on support systems or counterspaces in order to prove others wrong, overcome self-doubt, and see themselves as belonging in STEM (Borum & Walker, 2012; McGee and Bentley, 2017; Leyva, 2016, 2021a; Ong et al., 2018). In particular, Black and Latina women have lower rates of persistence among all students in STEM fields (Johnson, 2012) and indicate higher gender stereotype threat and disengagement from mathematics compared to White female students (Casad et al., 2019).

Black female students in STEM share experiences of structural racism, sexism, race-gender bias, microaggressions, discrimination, feelings of isolation, difficulty finding partners for class assignments, and exclusion from study groups in STEM settings at PWIs (McGee &

Bentley, 2017; Borum & Walker, 2012; Ireland et al., 2018; Fries-Britt et al., 2013). They encountered stereotypes as Black women and felt the need to prove their worth and intelligence as one of the few Black students and endured negative experiences to successfully persist in STEM. Furthermore, Black female students report that they have fewer interactions with faculty compared to their Black male peers (Strayhorn & Saddler, 2009).

Charleston and colleagues (2014) explored the racialized and gendered experiences in the computing sciences and found that Black women who persisted see their racial and gender identities among the most salient of their identities. Their racial identities became more salient than their gender identities in certain contexts, or vice versa. These women also emphasized how race and gender were intersecting factors that negatively influenced their educational experience. They also described experiences of stereotype threat, exclusion, isolation, being discouraged by faculty, not feeling welcomed to work with other peers, and questioning their belonging in their field at several points in the STEM education experience.

Winkle-Wagner (2015) reviewed 119 studies on Black female college students and found that most researchers focused on individual student attributes and very few studies focused on institutional factors that may foster or hinder Black female students' success. Winkle-Wagner warned that focusing on individual level factors is harmful because inequities may be attributed to individual deficiencies rather than evidence of larger structural, sociocultural, or institutional issues. Furthermore, there was little interactional analyses of race, gender, class, or other categories limiting a holistic consideration of the unique needs of Black female students.

Although limited, the bulk of the research on minoritized female students has focused on Black women in PWIs, and more research is needed to understand the experiences of Black women (as well as Latina, Native American, Asian, and multiracial women) in more diverse

STEM contexts (Ong et al., 2011; Ireland et al., 2018). While understanding contextual factors are important, extant research tends to focus on negative factors and there has been less emphasis on positive factors which may potentially increase student integration into the STEM community (Estrada et al., 2018). Therefore, we need a better understanding of how STEM classrooms hinder as well as promote opportunities for learning, and how formal structures can be built to minimize feelings of isolation, increase participation, and foster a sense of belonging.

Minority Serving Institutions and Women's Colleges' Success

Historically Black Colleges and Universities (HBCU)

A growing body of research shows that the right support structures can bolster female minoritized students' rates of participation and persistence in STEM education. Research on HBCUs, for instance, provides evidence that with diverse support systems, students can thrive and be successful in STEM environments (Museus et al., 2011; Ong et al., 2011; Perna et al., 2010). For example, Spelman College, the nation's oldest HBCU for women, has a high record of graduating Black women in STEM. One-third of its graduates are STEM majors, and Spelman is the second leading undergraduate institution that produces Black STEM PhDs (McNair, 2009). In 2006, Spelman was first in awarding the highest number of bachelor's degrees in mathematics, third in physical sciences and fourth in biological sciences to Black women (Perna et al., 2010). The overwhelming accomplishment of HBCUs such as Spelman is credited to a close-knit community and culture in which their students are academically successful regardless of academic preparation, socioeconomic status, or environmental circumstances. I expand on each of these factors below.

What drives this success? First, HBCU students describe feeling a strong sense of belonging within their major and larger campus community (Winkle-Wagner & McCoy, 2018;

Toldson, 2018). The body of literature on HBCUs has identified two common characteristics that contribute to this strong sense of belonging: (a) strong peer community, and (b) supportive faculty-student relationships (Palmer & Gasman, 2008; Gasman & Nguyen, 2014; Upton & Tanenbaum, 2014; Ellington & Frederick, 2010). A strong peer community appears to be instrumental in bolstering Black female students' persistence and academic success in STEM. In a study across ten HBCUs, for instance, Nguyen and colleagues (2021) found that Black female students benefit from a cooperative and collaborative culture; these students described their STEM courses as challenging, but working and learning together helped them become more confident to persevere in STEM.

The second factor, strong faculty support, is linked to student effort, positive academic outcomes, and persistence in STEM (Cole & Espinoza, 2013; Flowers & Banda, 2013; Museus et al., 2011; Lundberg and Schereiner, 2004; Borum & Walker, 2012). Faculty at HBCUs acknowledge that many of their students may have gaps in their STEM preparation but assume that it is the institution's responsibility to provide the necessary support in order to strengthen skills (Gasman et al., 2017). HBCU faculty are more likely to hold the premise that all students are inherently intelligent and have the potential to succeed, and they perceive gateway courses as a way to help students progress in their STEM trajectory (Gasmen & Nguyen, 2014; Perna et al, 2009). HBCU students report having more positive relationships and more frequent interactions with faculty than their counterparts at PWIs (Hurtado et al., 2011; Toldson, 2018). Moreover, students at HBCUs describe their faculty as behaving in a manner that prioritizes the needs of students, both inside and outside the classroom (Hurtado et al, 2011; Gasman et al., 2017; Perna et al., 2009, 2010). Scholars studying success of HBCUs have not explicitly addressed sense of belonging, but the ideas of connectedness and community have frequently come up as common themes.

Unlike their counterparts at HBCUs, Black students at PWIs report feelings of loneliness, alienation, shame, disrespect, and feel that their education experiences and low levels of support negatively impact their sense of belong (Booker, 2016). Black and Latinx students describe experiencing culture shock when they first saw the lack of racial diversity at their PWI which made them feel like an outsider. Minoritized students' low sense of belonging at PWIs could have important implications for their persistence in STEM programs. In contrast, minoritized students perceived their STEM programs to be diverse and inclusive, and experienced family-like and supportive environments at HBCUs (Winkle-Wagner & McCoy, 2018). In summary, Black students at HBCUs have higher academic outcomes, higher levels of satisfaction, a more nurturing experience, better relationships with faculty and peers, and a higher sense of belonging than Black students at PWIs (Toldson, 2018; Winkle-Wagner & McCoy, 2018).

Hispanic Serving Institutions (HSI)

The open access institution in this study has recently been designated as a Hispanic Serving Institution so in this section I review studies on HSIs. HSIs are the fastest growing Minority Serving Institutions (MSIs) due to changing demographics in the U.S. (Cole & Espinoza, 2013). Although about 268 HSIs make up 10% of all postsecondary institutions, they enroll half of all Latinx students, and award 40% of all bachelor's degrees to Latinx students, 20% of which are in STEM fields. HSIs also enroll 19% of Asian American, 13% of American Indian, and 11% of Black students. (Palmer et al., 2013; Cole & Espinoza, 2013). Unlike HCBUs, HSIs' designations are based on student enrollment numbers (at least 25% Latinx undergraduate enrollment) rather than historically being connected to a specific racial or ethnic group (Perna et al., 2010). The proportion of Latinx students at HSIs range from 25% to 99% of the student population and so Latinx students may not be the largest ethnic group at HSIs (Dowd et al., 2013). Latinx students are largely concentrated at HSIs, are less likely to complete their college degree compared to their White and Asian peers and take longer than four years to graduate on average (Strayhorn, 2019). In addition, a higher proportion of Latinx students receive the Pell grant, are first-generation, and attend college part time at HSIs (Crisp et al., 2009).

Studies on HSIs are sparse compared to studies on HBCUs, but extant research indicate that HSIs positively impact Latinx students by providing various academic and social support programs to increase retention and completion rates (Ong et al., 2011; Palmer et al., 2013; Stage & Hubbard, 2007). HSIs also contribute to promoting STEM degree attainment of Latinx students; for example, HSIs were among the four of the five top institutions that produced Latinx STEM graduates in 2001. Similar to HBCUs, Cole & Espinoza (2013) found that HSI faculty's support and encouragement positively influence STEM outcomes of Latinx students. However, more research is needed to identify the factors that contribute to equitable outcomes for students at HSIs (Crisp et al., 2009).

A multi-institutional case study (Dowd et al, 2013) of HSIs found that STEM faculty of Latinx heritage, who understood the inequities affecting Latinx students, were committed to expanding educational opportunities for Latinx students. These faculty members understood what it was like being an outsider and used their positions and networks to be institutional advocates for Latinx students. Dowd and colleagues stated that the problem is that there are not enough institutional agents at HSIs to bring a cultural change at HSIs. In addition, HSIs may not be implementing inclusive practices and pedagogies to the same degree as HBCUs to counter racialized learning experiences. While HBCUs expect student success and operate with the underlying assumption that all students are capable of high educational achievement, similar acknowledgement have not been found at HSIs with respect to the experiences of Latinx students in STEM.

HSIs implement various approaches to support their Latinx students but the most common strategy is using special programs on campus through tutoring, career guidance, research opportunities, and student-faculty mentoring. However, these programs only serve a small percentage of students and are dependent on external funding. Furthermore, the special programs aim to give students strategies to navigate STEM pathways instead of transforming ineffective institutional practices and policies (Dowd et al., 2013).

Latinx students face challenges at PWIs similar to those faced by Black students, but there is limited comparable work examining whether Latinx students benefit from attending an HSI versus a PWI. In one study, Hurtado et al. (2011) found no significant difference in frequency of interaction between Latinx students and faculty at HSIs and PWIs. For some Latinx students, the race of the faculty member was not as important as their perception of faculty's caring about students. In another quantitative study, Laird and colleagues (2007) reported that the Latinx senior students' level of engagement, satisfaction with college, and gains in overall development at HSIs were similar to the Latinx senior students at a PWI. However, Latinx students tend to report lower sense of belonging at PWIs than their White peers (Strayhorn, 2019).

Laird et al. (2007) hypothesized that the positive impact of attending an HSI for Latinx students is probably less than attending an HBCU for Black students when compared to similar students at PWIs. This may be due to the differences in the historical development and the diverse institutional cultures of these unique institutions. Unlike HBCUs, many HSIs did not begin as HSIs and are in the midst of learning how to best serve all students including Latinx students. Certainly, more research on HSIs is needed to discern whether they have the same effect on Latinx undergraduates as HBCUs have on Black students. However, Museus et al. (2011) claimed that there is no doubt that HSIs serve as important STEM pathways for Latinx students.

Sense of belonging was not a salient theme in the HSI literature. However, in one quantitative study, Maestas and colleagues (2007) examined sense of belonging at the University of New Mexico, a HSI, a diverse minority-majority institution. The authors found that a students' financial stability, participation in academic support programs, faculty interest in a student's development, living on campus, participation in extracurricular activities, and socializing with different racial/ethnic groups other than their own positively impacted students' sense of belonging at this HSI.

Interestingly, even in HSIs, Latina students are less likely to major in STEM than Latino students (Crisp et al., 2009). Despite this finding, there remains a lack of studies that address the experiences of minoritized women in HSIs (Ong et al., 2011). My study will expand the literature by exploring minoritized female students' experiences and sense of belonging in mathematics classrooms at a diverse HSI.

Women's Colleges

Women's colleges have a long history of providing women access to higher education. Advocates of women's colleges claim that these institutions provide a superior learning environment leading to greater gains in academic development, involvement, self-esteem, and self-confidence. Women attending women's colleges are 1.5 times more likely to earn bachelor's degrees in life/physical sciences or mathematics than their peers at coeducational institutions. Furthermore, students at women's colleges report feeling more satisfied with their college experience and interactions with faculty. Higher percentages of students at women's colleges are enrolled in STEM majors and graduates from women's colleges are more likely to earn doctorates in a wider range of major fields (Kinzie et al., 2007).

Kinzie and colleagues' (2007) quantitative study compared women attending women's colleges and women attending coeducational colleges. They discovered that students at women's colleges scored higher on active and collaborative learning, reported higher levels of academic challenge, and experienced higher faculty expectations of students. Their findings echo similarities of HBCU faculty; faculty members at women's colleges are more accessible in and outside of class compared to faculty at coeducational institutions. The high levels of student-faculty interaction led to opportunities for mentorship, advice, encouragement, recommendations for awards, internships, and research opportunities.

Similar to high levels of supportive peer interaction at HBCUs, female students at women's colleges participate more actively during class, work with their peers more often in and out of class, and tutor other students more frequently than women at coeducational institutions. Furthermore, students have access to more female faculty and more opportunities to participate in student leadership. Women's assessment of their academic ability during college increased for students at women's colleges and decreased for women students at coeducational institutions (Kinzie et al., 2007; Whitten et al., 2007). Cassidy (2016) stated that at a women's college, female students do not face gender biases and have equal access to research and mentoring opportunities. Furthermore, female students in STEM departments at women's colleges feel a stronger sense of belonging in an environment with majority female mentors and peer groups.

Moreover, Rosenthal et al. (2011) argued that single-gender schools and programs promote women's engagement and persistence in STEM fields. They studied a single-gender program for female STEM majors (24 White, 15 East Asian, 14 South Asian, five Black, three Latina, seven other) at a coeducational university. The program provided financial support, exposure to STEM research, social and academic events, courses, mentoring from female STEM faculty and graduate students for first year students because the first year was identified as a high-risk transitional period for women in STEM. Their quantitative findings indicated that greater perceived social support from people within the program predicted a greater sense of belonging in the STEM major and at the university.

Female mathematics majors at a women's college in Gavin's (1996) study shared that the college environment and professors encouraged them to persist as a mathematics major. They appreciated that questions were welcomed, students were treated with respect, and the classroom environment was comfortable and supportive. However, some participants developed a negative attitude towards mathematics and found some of their course content too abstract and irrelevant to their lives.

Kinzie et al. (2007) considered within women's college differences and found that senior Black and Asian students reported fewer interactions with faculty compared with White students. Senior Black students reported receiving significantly less support and were less satisfied with their college experience than White students, while Asian students were also less satisfied than White students. These findings suggest that minoritized female students may still experience their learning environment differently from White students even in a women's college. Kinzie and colleagues suggested that women's colleges should examine HBCUs to improve undergraduate experience for Black students.

Open/Broad Access Institutions

Higher education is becoming more stratified by both race and class, while minoritized simultaneously students are attending college in greater numbers. White students captured most of the enrollment growth at the most selective and well-funded four-year colleges, while Black and Latinx students represent most of the enrollment growth at open-access two and four-year colleges (Rendon, 2020). The need for educating diverse college students is most evident at open access institutions that enroll majority of students who have been historically underrepresented in higher education. The success and efficacy of open access institutions is largely dependent on the success of their diverse students. Unfortunately, colleges have been least effective in producing successful outcomes for first-generation Black and Latinx students particularly at institutions that are open access and that serve primarily minoritized students (Hurtado et al., 2012). More research is needed on how open access institutions, such as the institution in my study, can create supportive structures and foster meaningful peer and faculty relationships for minoritized students.

Sense of Belonging Literature

Much of the research on belonging addresses minoritized students' sense of belonging at the campus level, rather than the classroom level, and is largely situated in four-year PWIs or research institutions (Hurtado et al., 2015; Zumbrunn et al., 2014; Hausmann et al., 2007). Research has indicated that sense of belonging is correlated with positive outcomes such as academic achievement, retention, persistence, and mental health (Strayhorn, 2019; Gopalan & Brady, 2019). Conversely, a lack of sense of belonging is the primary cause of student opting out from their STEM major, particularly among minoritized and female students, even when achievement is high (Strayhorn, 2019; Good et al., 2012). Black, Latinx, and Asian Pacific

American students report a lower sense of belonging to their campus than White students (Strayhorn, 2008; Johnson et al., 2007; Gopalan & Brady 2019). In particular, minoritized female students are more likely to report a lower sense of belonging that also wanes over time compared to other groups, even in diverse institutions (Rainey et al., 2018).

Frequent validating interactions with supportive faculty, engaging pedagogies, positive interactions with diverse peers, a welcoming campus culture/climate, racial/gender diversity, living on campus, and positive perception of one's cultural identity positively contribute to minoritized students' sense of belonging (Strayhorn, 2008; Hurtado et al. 2015; Hurtado & Carter, 1997; Velasquez, 1999; Johnson et al., 2007; Locks et al., 2008; Gasman & Nguyen, 2014; Nguyen et al., 2021; Museus et al., 2017; Lee & Davis, 2000). When students feel a sense of belonging in the educational environment, they are willing to take risks, challenge themselves, and commit to their major (Booker, 2016). Consequently, sense of belonging is an important factor in retaining all students especially minoritized students (Maestas et al., 2007).

Perceptions of Campus Climates

Studies show that perception of a positive campus climate for diversity, as well as positive race-related interactions and experiences are significantly related to higher sense of belonging to their campus for Black, Asian, and Latinx students at PWIs (Hurtado & Carter, 1997; Hurtado & Ponjuan, 2005; Johnson et al., 2007; 2012; Locks et al., 2008; Maestas et al., 2007; Lee & Davis, 2000). Hurtado and Alvardo (2015) established that low racial diversity on campus is associated with more frequent experiences of discrimination and a lower sense of belonging for even the highest achieving Black and Latinx students. Campus climate also plays a critical role in women's satisfaction and retention in STEM; research indicates that women describe their STEM educational climate as “chilly” which negatively influences their sense of belonging (Ong et al., 2011; Casad et al., 2018).

Campus climate research explores students’ perceptions of belonging and inclusivity. Institutions’ embracement of diversity and visible gender and racial diversity within the discipline and institution influence how students perceive their STEM programs (Winkle-Wagner & McCoy, 2018). However, a diverse study body is a necessary but not sufficient condition for student success, as discrimination does not completely disappear even at diverse colleges (Locks et al., 2008). Institutions must intentionally create conditions for diverse peer interactions that will result in benefits of diversity (Hurtado et al., 2012). Few studies have examined the role that campus climate plays in promoting or discouraging minoritized students’ success in undergraduate STEM fields. However, as research on HBCU’s welcoming and supportive campus climate suggest, minority serving institutions have been effective in creating supportive environments which can lead to successful outcomes for minoritized female STEM students (Strayhorn, 2013). Hurtado and colleagues (2015) argued that both campus climate and sense of belonging are significant factors in college student retention and degree completion.

Sense of Belonging at the Campus Level

Hurtado and Carter (1997) conducted one of the earlier studies exploring sense of belonging to the college, analyzing national data of Latinx students with high PSAT scores. They found that students who frequently discussed course work with other students outside class and held memberships in external religious and social organizations reported a higher sense of belonging. Notably, Latinx students’ GPAs in the second and third year were not significantly related to their sense of belonging, suggesting that academic performance did not necessarily affect Latinx students’ sense of belonging with the college.

Contrastingly, a different study involving 289 Latinx and 300 White students at four-year institutions showed that grades and time spent studying positively influenced Latinx students' sense of belonging suggesting that high-achieving students may feel more connected to campus (Strayhorn, 2008). The greatest impact on campus belonging was frequent interactions with diverse peers with greater effect on Latinx students compared with White students. However, Latinx students reported lower levels of sense of belonging than White students. Likewise, Hurtado and Ponjuan (2005) found that among 370 Latinx students across nine public institutions, those reporting positive interactions with diverse peers and participation in academic programs reported higher sense of belonging.

Similarly, in a study examining a national sample of first year students, Johnson and colleagues (2007) indicated that Black, Latinx, and Asian Pacific American students reported lower sense of belonging on their campuses than White students. Students from all racial/ethnic backgrounds who experienced a smooth academic and social transition to college and perception of a positive and inclusive residence climate, also reported a higher sense of belonging to their campuses. Contrary to some studies, interaction with professors was not significantly related to sense of belonging for any racial/ethnic groups. Notably, Latinx students were the only racial/ethnic group for which interactions with diverse peers were significantly related to their sense of belonging, a finding similar to those in Hurtado and Carter's (1997) and Strayhorn's (2008) studies.

Gopalan & Brady (2019) also found that belonging was positively associated with persistence but Black, Latinx, and first-generation students reported lower belonging than their peers at four-year colleges. In addition, student belonging at two-year colleges was lower than those at four-year colleges and not significantly associated with persistence. The authors suggested that this difference may mean that two-year college students face greater structural challenges, or that institutional belonging is less important than belonging in a course or major. A surprising finding was that Black, Latinx, and first-generation students at two-year colleges reported higher levels of belonging than their White, Asian, and continuing-generation peers, respectively. Female students also reported higher belonging than male students at two-year colleges.

Hausmann, Schofield, and Woods (2007) found that peer support was associated with an increase in sense of belonging for Black students and not White students at a large public PWI. After controlling for demographic variables, faculty and peer interactions, parental and peer support, and academic integration, the authors found that sense of belonging was a statistically significant predictor of intent to persist at the beginning of the academic year. Their results indicate that supportive peer networks may be a salient factor in Black students' sense of belonging.

Belonging at the Classroom Level

Although most belonging studies are situated at the campus level, the classroom serves a critical role in promoting sense of belonging because it is the primary context where student and faculty interactions take place, and may even determine which students decide to remain in STEM majors (Seymour & Hewitt, 1997; Riegel-Crumb et al., 2019). In the few studies on classroom belonging, belonging has been linked to academic motivation, engagement, confidence, and achievement in that class (Freeman et al., 2007; Zumbrunn et al., 2014; Wilson et al., 2015; Kirby & Thomas, 2022). Students feel more connected in classes with instructors who are perceived as caring, open, supportive, competent, and incorporate active learning pedagogies that encourage peer collaboration (Wilson et al., 2015; Kirby & Thomas, 2022;

Booker; 2007). Despite the importance of sense of belonging for minoritized female students in STEM, research in this area remains limited (Strayhorn, 2019; Rainey et al., 2018; Johnson, 2012; Booker, 2016), particularly in the classroom context, which is often the center of students' experience. In this section, I highlight key studies on the sense of belonging at the classroom level.

Wilson and colleagues' (2015) study examined belonging across three levels (classroom, major, and university) among diverse STEM undergraduates across five institutions (HBCU, private, research, teaching, women's college). They found that class belonging, rather than belonging to the major or university, was most consistently associated with engagement in STEM coursework, and higher levels of participation. University belonging was an important factor at only the large research institution, and not the other four types. Sense of belonging to an academic major was also a significant factor associated with engagement for some of the schools. Their results indicate that regardless of school size, geographical location, or institutional culture, classroom sense of belonging cultivated through peer and faculty relationships is strongly related to students' feelings, motivation to participate, and learning outcomes. This study highlighted the importance of supporting belonging among STEM students, especially within individual classroom contexts as demonstrated by the significant links between class belonging and engagement across all five institutions.

Hoffman and colleagues (2002) developed a Sense of Belonging Instrument that assessed first year students' perceptions of academic and social support from peers and faculty, isolation from peers, and comfort in classroom environments at a PWI. Perceived peer and faculty support emerged as factors that were important in the classroom environment to institutional commitment and intention to persist. They found that first-year students involved with learning communities reported a higher sense of belonging, higher levels of faculty support, greater peer support, and greater classroom comfort, compared to those students enrolled in general courses.

Two studies further focused on the connection between belonging and academic outcomes. Zumbrunn et al.'s (2014) mixed methods study showed that student perceptions of belonging were linked to motivation in educational psychology classes for their student sample (73% female, 92% White, 2% Black, 3% Latinx). Instructor academic and social support was a key contributor to students' feelings of belonging. Only students from the high belonging group reported feeling accepted, supported, respected and valued by their classmates. Similarly, Freeman and colleagues (2007) found that when students (216 White and 15 Black, 60 men, 162 women) felt a sense of belonging in a particular class (non-major sections of biology, psychology and English), they reported higher motivation and confidence levels in relation to the class. Students' perceptions of their instructor as encouraging, helpful, and prepared for class contributed to their sense of belonging. Surprisingly, class belonging was not found to contribute to sense of belonging to the university.

Collectively these studies show that classroom-level sense of belonging is a critical factor in student success as the classroom context provides students with a regularly scheduled setting for interactions and engagement with peers and faculty. For example, students who reported a strong sense of belonging to class peers reported higher confidence in their classes (Freeman et al., 2007), increased engagement (Wilson et al, 2015); and motivation (Zumbrunn et al., 2014). The few studies on class-level belonging point to the importance of supportive faculty, peers, and classroom environment. Additional work is needed, however, to understand how classroom structures and pedagogies contribute to classroom belonginess, particularly among minoritized female students.

Belonging to Mathematics

Few studies have investigated sense of belonging within mathematics contexts specifically. Good and colleagues (2012) examined sense of belonging in the mathematics domain among high-achieving calculus students (47% White, 3% Black, 21% Asian, 5% Latinx, and 24% other) at a highly selective university and found that (1) students' sense of belonging can predict their desire to pursue and remain in the discipline; and (2) two messages women may hear in their mathematics environments – that mathematics ability is a fixed trait and that women have less of this ability than men – may decrease women's sense of belonging in mathematics.

Furthermore, sense of belonging was found to be an important predictor of mathematics anxiety, mathematics confidence, mathematics achievement, academic choices, and perceived usefulness of mathematics. Specifically, women's sense of belonging decreased over the semester if they perceived their academic environment to convey a high degree of gender stereotyping and a fixed view of intelligence, which in turn led to lower levels of intent to take mathematics in the future and lower course grades. In contrast, female students maintained a sense of belonging to mathematics even when they perceived their environments as highly gender-stereotyped if they perceived their environment to be supportive of a malleable view of intelligence. These results highlight the effect of learning environments on a woman's sense of belonging to mathematics, and that belonging can impact one's academic achievement and career aspirations. Good et al.'s study was the first to establish students' sense of belonging to mathematics as a new and an important predictor of mathematics achievement as well as mathematics anxiety, confidence, perception of usefulness, and intentions to remain in mathematics for both men and women.

Barbieri & Miller-Cotto's (2021) extended Good et al.'s (2012) findings to middle school students and their research established that (1) sense of belonging to mathematics predicts algebra learning; (2) minoritized students experience lower feelings of belonging in mathematics; and (3) their lower sense of belonging partially explains fewer improvements in algebra performance by the end of the unit. They examined the connections between sense of belonging in mathematics and mathematics self-concept, importance, interest, and ability among eighth-grade students. Their results demonstrated that students' sense of belonging in mathematics was the only significant predictor of algebra learning and the only significant predictor of motivation and beliefs at a racially and ethnically diverse public middle school. Black, Latinx, and multiracial students displayed significantly lower sense of belonging to mathematics than White and Asian students, even though their prior algebra knowledge (measured by a pretest) did not differ. Furthermore, Black, Latinx, and multiracial students' interest in mathematics, perceptions of mathematics importance, and mathematics self-concept were just as high as White and Asian students.

Fostering Belonging in Undergraduate Mathematics Classrooms

While previous research has established the importance of belonging within the broader domain of mathematics, more recent studies have focused on interventions or factors that influence belonging in undergraduate mathematics classrooms. Several studies across diverse educational contexts have identified key factors that enhance students' belonging.

Recent mixed-methods studies by Griffin (2023), McGrane and Rasmussen (2023), and Lahdenpera and Nieminen (2020) underscored the impact of interactive learning environments on students' sense of belonging. Griffin's (2023) study with 46 female undergraduate calculus students found that 91% identified either group work or interactive lectures as the most influential factors contributing to their belonging, with significant increases in belonging, competence, and social connectedness over a seven-week period. Similarly, Lahdenpera and Nieminen's (2020) study of 89 Finnish university mathematics students identified the "learning environment" as a critical factor, emphasizing how student-centered teaching approaches foster inclusion within the mathematics community.

Recent research at Hispanic-Serving Institutions has illuminated critical factors affecting student belonging in mathematics classrooms. McGrane and Rasmussen's (2023) investigation of calculus support courses revealed that mentorship and instructor engagement significantly improved students' belonging compared to students in traditional courses. Cawley and Wilson (2024)'s study in a calculus 1 or abstract algebra course found that majority of students felt like they do not belong in the mathematics classroom. Their research documented low but concerning rates of microaggressions, with 16% experiencing racial microaggressions and 10% experiencing gendered microaggressions that undermined their classroom belonging.

Socioeconomic factors also play a crucial role in student belonging. Urbieta's (2022) mixed methods study at a Hispanic-Serving community college demonstrated that students from low socioeconomic backgrounds reported significantly lower levels of belonging in calculus and faced numerous academic challenges, including housing instability and work-related demands. This study suggested that comprehensive support systems must address both academic and socio-economic barriers to effectively foster belonging in mathematics classrooms. Together, these studies emphasize that active learning strategies, faculty engagement, and collaborative environments are essential for cultivating students' sense of belonging in undergraduate mathematics education.

Minoritized Female Students' Sense of Belonging in STEM

In this section, I review the literature that focuses specifically on minoritized female students' sense of belonging in STEM. There is a gap in the sense of belonging literature that addresses the intersection of gender with race. Many studies regarding racial differences do not consider gender identity, as these studies are often conducted at PWIs and leave the experiences of minoritized women in STEM classrooms largely unexamined. The experiences of minoritized women's belonging are further excluded in other studies about belonging in STEM fields that discuss only racial identity. Intersectional work that investigates minoritized women's experiences in STEM (Borum & Walker, 2012; McGee and Bentley, 2017; Leyva, 2016; Ong et al., 2018; Winkle-Wagner, 2015) exists, but literature addressing minoritized women's sense of belonging (Rainey et al., 2018; Charleston et al., 2014) especially in introductory mathematics courses remains limited.

Johnson's (2012) quantitative study of first-year women in STEM across 34 PWIs revealed that minoritized women faced distinct challenges. Among participants (5% Black, 3% Latina, 1% American Indian, 4% multiracial, 15% Asian Pacific, and 70% White) being a minoritized female student negatively predicted campus belonging. Positive campus racial climate perceptions and academic self-confidence were significantly related to students' overall sense of belonging as supported by prior research. The campus racial climate may have been particularly salient due to the lack of racial and ethnic diversity in STEM departments in PWIs for minoritized female students.

Similarly, Rainey et al. (2018) conducted a mixed method study of 210 college seniors from diverse gender, racial, and socioeconomic backgrounds across 16 campuses in North Carolina. The authors reported that White students reported feeling a sense of belonging in

STEM. Minoritized male students reported a lack of sense of belonging, and minoritized female students reported feeling a sense of belonging less frequently than any other demographic group. Interestingly, the minoritized female students were seniors and yet did not feel that they belonged in their STEM major in which they were about to receive a degree. Sense of belonging was associated with peer relationships, students' academic confidence, and interest in their major. This study is unique because it considers the intersections of race and gender in their analysis.

Black female students report a lower sense of belonging in STEM compared to any other demographic group, including Black male students (Johnson, 2012). They share that their intersectional racial and gender identities are the most salient in the STEM environment which makes them question their belonging throughout their STEM education pathway (Charleston et al., 2014). Clearly, we need more research to identify the ways in which STEM educational environments work to discourage minoritized female students and better understand factors that positively impact their sense of belonging.

Importance of Interactions in the Classroom with Peers and Faculty

Studies indicate that minoritized female students develop their confidence and sense of belonging in STEM through academic and personal relationships. When examining sense of belonging in the classroom setting, two major themes emerge: faculty and class peers (Booker, 2016; Johnson et al., 2007). Cole & Espinoza (2013) noted that peer and faculty interactions are the most important aspect of the college experience for students attending minority serving institutions. In this section I explore these two factors, peer and faculty support, in more depth.

Peers

Positive interactions with diverse peers have been linked to a higher sense of belonging to the campus community for all students, emphasizing that the quality of interactions with diverse peers and not merely the presence of diverse peers is important (Locks et al., 2008; Zumbrunn et al., 2014). Perceived peer support important was found to be an important factor in students' sense of belonging (Hoffman et al., 2002) and is more salient for Black students' sense of belonging over time (Haussman et al., 2007; Booker, 2016).

Peer relationships and support are particularly important for minoritized women persisting in STEM (Espinosa, 2011; Rainey et al., 2018). Minoritized female students value working on group projects in class and helping another student (Ong et al., 2011). In contrast, Sims' (2008) study on Black women at a PWI revealed that some women successfully completed their degrees without making social connections within their university which could contradict research that maintains the importance of peer and faculty relationships. Fries-Britt & Holmes (2012) also found that high achieving Black female physics students struggled in maintaining relationships with faculty and peers. This discrepancy must be explored as research on the role of peers for minoritized female students' success is scarce (Winkle-Wagner, 2015). It is possible that the Black women found other support systems to be resilient despite experiencing challenges without relying on peer support. Therefore, future research should explore ways in which institutions can establish a supportive peer culture for minoritized women.

Faculty

Faculty also play an essential role in creating inclusive educational environments for student success (Hurtado et al., 2015). Research conducted in elementary, middle, and high schools have demonstrated that perception of caring and supportive teachers enhances students' sense of belonging (Kirby & Thomas, 2022). The same finding applies to the college setting: empathetic and caring faculty positively influence college students' sense of belonging in the classroom (Hoffman et al., 2002; Micari & Pazos, 2012). Students in classes where instructors encourage classmates to get to know one another at the beginning of the semester and facilitate group collaboration activities reported a greater sense of belonging (McKinney et al., 2006). Student-faculty relationship also positively predict grade as well as confidence for students in organic chemistry courses (Micari & Pazos, 2012). Together these studies indicate individual faculty can support students through building community and fostering a sense of belonging in class.

Additionally, Lundberg and Schreiner (2004) found that frequent and high-quality faculty-student interactions was the only variable that significantly predicted learning for all racial/ethnic groups (Black, Asian or Pacific Islander, Native American, Latinx, multiethnic, and White) across various institutions but was a stronger predictor of learning for minoritized students than White students. Battey et al. (2022) found that minoritized students (Black, Latinx, and White female students) emphasized the relational rather than content-related dimensions of instruction, such as faculty knowing who students are and how students' questions and responses are handled. Similarly, in Booker's (2006) qualitative study, six Black college women revealed that they persisted because their faculty were accessible, approachable, and took time to establish relationships inside and outside the classroom. Similarly, Latinx students indicated greater sense of belonging when faculty showed interest in them in a qualitative study (Maestas et al., 2007). However, Black students reported fewer satisfying relationships with faculty and perceived their relationships with faculty more negatively than other groups (Fries-Britt & Turner, 2001).

Contrary to other belonging literature, faculty interaction and peer interactions did not significantly contribute to students' overall sense of belonging in Johnson's (2012) study. Johnson suggested that this may be due to the number of first-year students in the sample yet to have established relationships with faculty or peers or students encountering challenges as women or minoritized women in the predominantly White and male STEM environment.

More research is needed on STEM faculty who have created supportive learning environments for minoritized female students and how these practices can be used to transform introductory STEM courses (Johnson, 2011; Perna et al., 2010). Extant literature indicates that students report having high levels of belonging and positive experiences with faculty who show that they care, embed active collaborative learning pedagogies, and create classroom structures where students feel connected to each other (Booker, 2016; Museus et al., 2011). Educators can create conditions that foster belonginess for all students through engaged teaching, providing academic support, encouraging messages, and building inclusive learning communities.

Summary

In this chapter I discussed the literature on gender and racial disparities in STEM, racialized and gendered experiences of students especially at PWIs, minority serving institutions and women's colleges, and sense of belonging research. A research gap identified in the review of the literature is the lack of research conducted on mathematics classroom-level belonging experiences. In particular, few studies focus minoritized female students and their intersectional gender and racial identities, and even fewer use qualitative approaches that incorporate student perspectives. Although research has shown that sense of belonging positively influences achievement and persistence, comparatively little is known about which factors increase or decrease minoritized female students' sense of belonging in mathematics classes at racially diverse, open access, minority-serving institutions.

CHAPTER 3

METHODOLOGY

In this chapter I describe the methodology used to investigate Black and Latina female students' sense of belonging in college algebra and precalculus. This study addressed three research questions: (1) How do Black and Latina female students' sense of belonging in the college algebra and precalculus classroom differ compared to students in other racial and gender groups? (2) How does Black and Latina female students' sense of belonging in college algebra and precalculus change from the beginning to the end of the semester? (3) How do Black and Latina female students describe their college algebra and precalculus learning environment, experiences, participation, persistence, support systems and challenges as it relates to their sense of belonging?

The study used a sequential explanatory mixed methods design, integrating both quantitative (pre- and post- sense of belonging surveys) and qualitative data (mathematics autobiography and individual interviews). I conducted the quantitative phase first to examine patterns in students' sense of belonging. The intent of an explanatory sequential design is to begin with quantitative methods and then use qualitative methods to interpret and expand upon the quantitative results and findings in more depth (Creswell, 2015).

The quantitative phase addressed Research Questions 1 and 2 by examining how Black and Latina female students' sense of belonging differs from other racial and gender groups in college algebra classrooms, and how it may change over the semester. The qualitative phase addressed Research Question 3 by using a thematic analysis approach to explore and understand

Black and Latina female students' sense of belonging in the college algebra classroom. I designed this phase to illuminate and explain patterns identified in the quantitative analysis, providing deeper insight into the experiences that shape sense of belonging. I selected this mixed methods approach because it allows for both the identification of patterns in belonging (quantitative phase), and the exploration of the lived experiences (qualitative phase), that provide a more comprehensive understanding of how Black and Latina female students experience belonging in mathematics courses. Figure 3.1 provides an overview of the study's design, showing how I structured the quantitative and qualitative phases to address the three research questions.

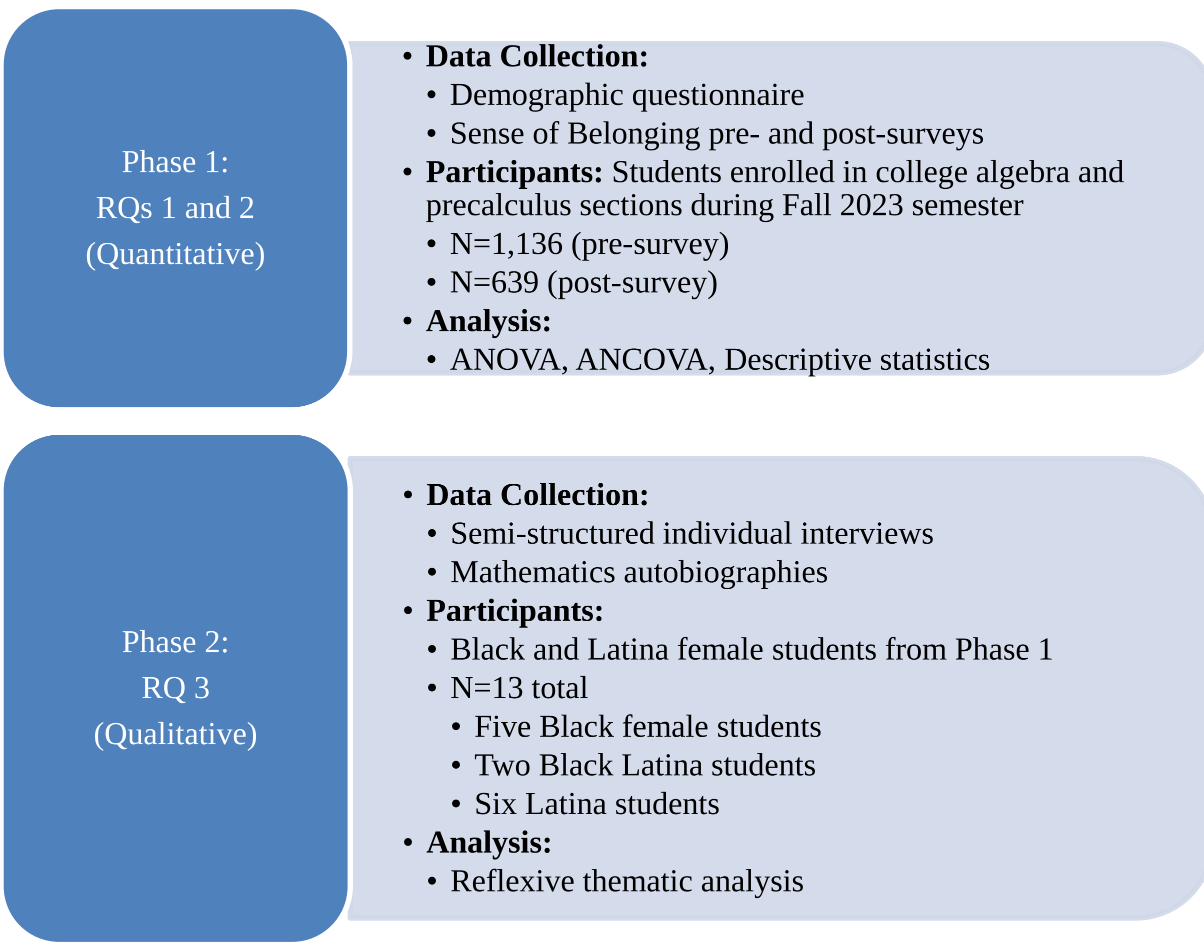

Figure 3.1 *Two Phase Mixed Methods Study Design*

Why Mixed Methods?

I chose a qualitative dominant mixed methods approach because it aligns with both my research questions and the theoretical perspectives guiding this study. The first two research questions are best addressed through quantitative methods, while the third research question requires qualitative methods to understand the students' experiences. Mixed methods approaches are well-suited for intersectionality research, as they can capture the complex, multidimensional nature of students' identities (Harper, 2011; Charleston et al., 2014). Furthermore, intersectionality research focuses on understanding the experiences of students and examines their intersecting social identities (racially minoritized and female) that mutually shape individual and group experiences (Museus, 2011). The purpose for mixing methods for this study is complementarity – to gain a broader, deeper, and more comprehensive understanding of sense of belonging. Results from the different methods serve to elaborate, clarify and enhance the overall interpretations (Greene, 2007).

Moreover, integrating quantitative and qualitative approaches may lead to a more complete contextual understanding of a phenomenon, which can inform policy and practice (Harper, 2011). Mixed methods approaches seek a richer and deeper understanding and generate both questions and possible answers through multiple approaches, as social phenomena are complex. Greene's (2007) framework for mixed methods research emphasizes three features that align with this study's goals: (1) seeking deeper understanding of complex social phenomena, (2) embracing multiple ways of knowing, and (3) engaging with the multifaceted nature of identity and difference.

Greene (2007) elaborated on these three features and their relevance to mixed methods research. First, she explained that the primary purpose of a mixed methods study is to better understand the complexity of social phenomena and to generate understandings that are broader, deeper, and more inclusive to honor the complexity of human experiences. Second, this approach embraces multiple philosophical and theoretical stances on knowledge, and accepts multiple and diverse ways of knowing, with the aim of developing more comprehensive insights. Third, mixed methods research provides a way to respect multiple ways of knowing, including a diversity of methodologies, and engage with diversity as multifaceted, situated, dynamic, and socially constructed dimensions of experience and identity.

The integration of quantitative and qualitative findings occurred during the interpretation phase. First, I explained the quantitative survey results that identified patterns and changes in sense of belonging through qualitative participant narratives from interviews and mathematics autobiographies. Second, I created a joint display to compare quantitative findings with qualitative themes, allowing for side-by-side analysis. Finally, I developed metainferences to a) synthesize findings from both phases, constructing a comprehensive picture of how Black and Latina female students experienced belonging, and b) identifying specific classroom experiences that contributed to their sense of belonging. Figure 3.2 illustrates the sequence of the mixed methods design, showing the progression from quantitative data collection and analysis to qualitative analysis and final integration.

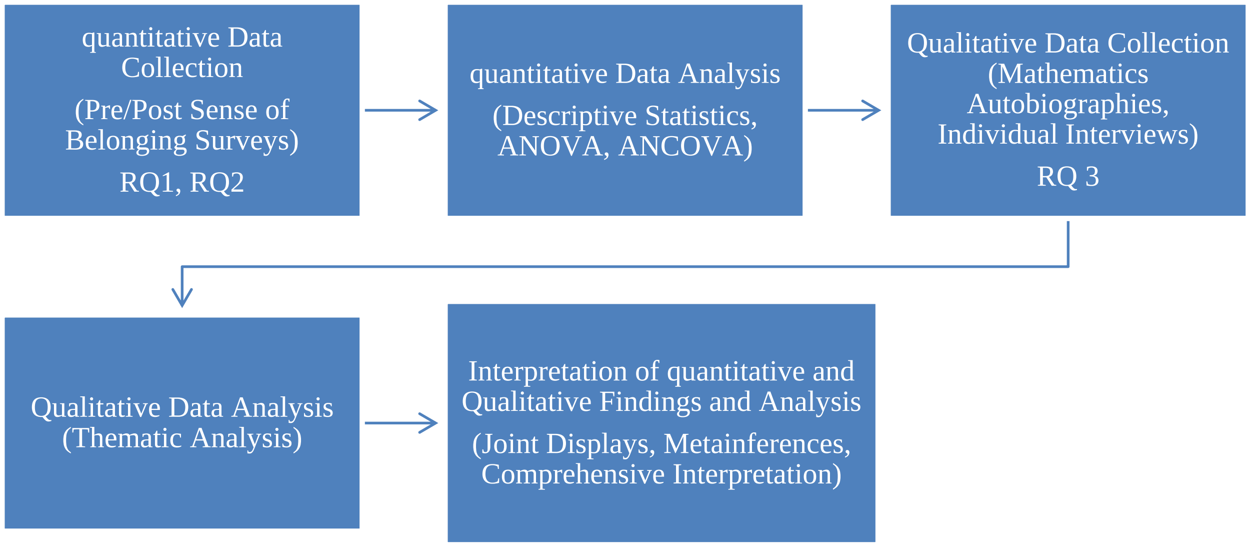

Figure 3.2 *Model of the Mixed Methods Explanatory Sequential Design*

Setting

The site for this study was an ethnically diverse, open-access, four-year, public college located in a suburban area near a large Southeastern city. Out of its 11,000 students, approximately 31.70% were Black, 27.29% were Latinx, 23.61% were White, 12.23% were Asian, 3.92% were two or more races, 0.23% were American Indian/Alaska Native, and 0.19% were Native Hawaiian/Pacific Islander. 58.72% were female and 41.28% were male students. Approximately 40% of the first-year class were first-generation students and over 50% were eligible for a Pell Grant. The college had also earned two specific designations under the Minority Serving Institutions (MSI) Program: Asian American and Pacific Islander Serving Institution (AAPISI) and Hispanic Serving Institution (HSI).

Phase 1: Quantitative Method

Student Participants

The survey participants were students enrolled in college algebra and precalculus courses during the Fall 2023 semester. College Algebra and Precalculus are typically the first two mathematics courses in the mathematics sequence (College Algebra, Precalculus, Calculus 1) that STEM majors take at this institution (see Table 1). I visited all 58 sections of College Algebra and Precalculus classrooms to administer pre-surveys during weeks 1 through 3 of the Fall 2023 semester at the beginning or end of class for 15 minutes. I visited all the classes again during weeks 11 through 14 to administer the post-surveys at the end of the Fall 2023 semester. The sample included seven sections of corequisite College Algebra with support, 37 sections of College Algebra, and 14 sections of Precalculus.

A total of 1,136 students completed the pre-survey (31.0% Black, 30.3% Latinx, 20.7% White, 13.4% Asian, and 4.5% Other; 51.7% female and 48.3% male), and 639 students completed the post-survey (30.4% Latinx, 29.1% Black, 21.1% White, 14.2% Asian, and 5.2% Other; 50.4% female and 49.6% male). Of these students, 631 completed both surveys, representing a 55.5% retention rate from pre- to post-survey. The students’ mean age was 19.08 years for the pre-survey respondents. Students self-reported their race/ethnicity and gender. Figure 3.3 displays the stacked bar chart of the distribution of self-identified gender within each race/ethnicity group of the participants in the pre-survey. Figure 3.4 shows the distribution of students by enrolled mathematics course for the pre-survey. Table 3.1 shows the declared academic majors of participants in the pre-survey.

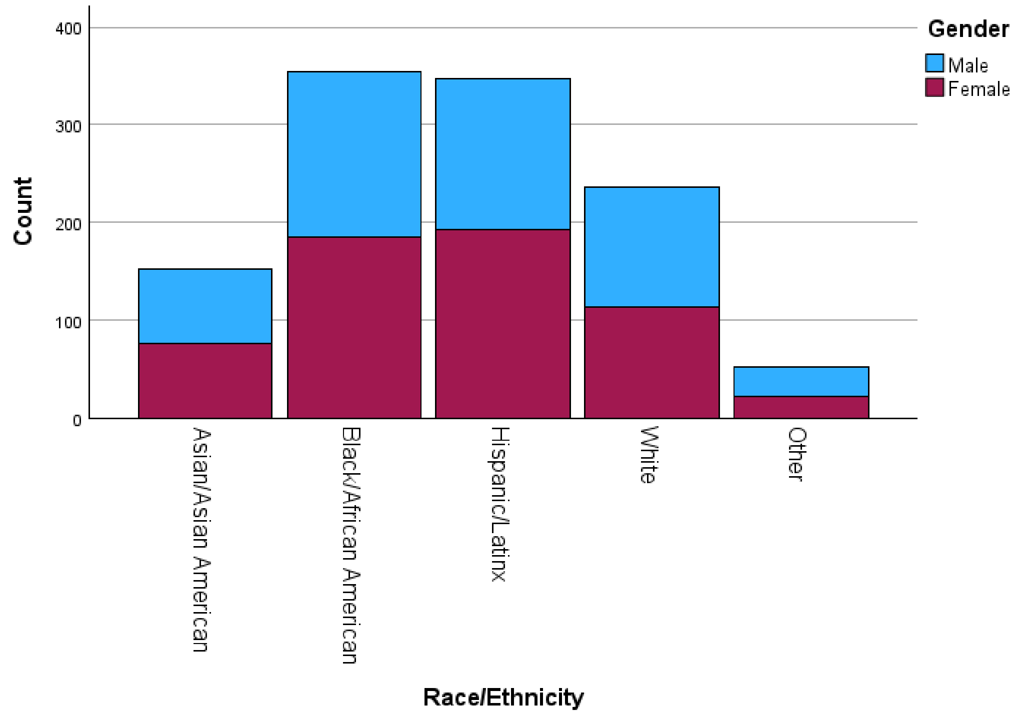

Figure 3.3 *Pre-Survey Participant Distribution by Race/Ethnicity and Gender (N = 1136)*

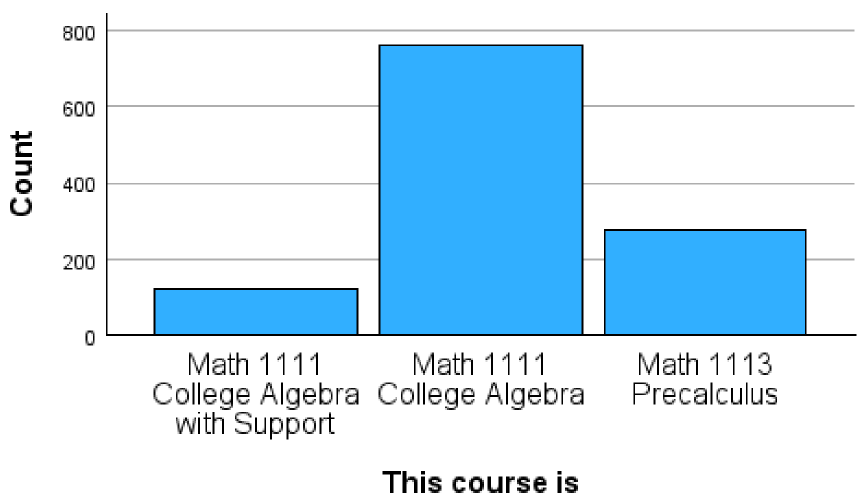

Figure 3.4 *Pre-Survey Participants by Mathematics Course*

Note. Most participants were enrolled in Math 1111 (College Algebra), with smaller numbers in Math 1111 (College Algebra with Support) and Math 1113 (Precalculus).

Table 3.1 *Pre-Survey Participants by Declared Academic Major (N = 1,159)*

		Frequency	Percent
Majors	Dual Enrollment	81	7.0
	Biology	155	13.3

	Chemistry	20	1.7
	Environmental Science	26	2.2
	Exercise Science	74	6.4
	Information Technology	250	21.5
	Mathematics	44	3.8
	Other	399	34.4
	Undecided	110	9.5
	Total	1159	99.7
Missing	System	3	.3
Total		1162	100.0

Note. This table displays the distribution of declared or intended majors among participants, with three cases missing.

Mathematics Faculty

In Fall 2023, there were 44 full-time mathematics faculty (47% White, 29% Asian, 18% Black/African American, 4% Hispanic, and 2% Other; 53% male and 47% female.) Of the 44 full-time faculty, six taught Math 1111*, 18 taught Math 1111 with support, and nine taught Math 1113. Additionally, four part-time faculty taught Math 1111, and one taught Math 1113.

Brief Description of Mathematics Courses

All STEM majors at this institution (with the exception of Exercise Science majors) are required to take Calculus I as their mathematics requirement. However, most students at this institution first take College Algebra (three credit hours), then Precalculus (four credit hours), and then Calculus (four credit hours). Students who do not meet the placement requirements for College Algebra are placed into College Algebra with Support (five credit hours). In Fall 2023, College Algebra and Precalculus sections were capped at 30 students. College Algebra with Support classes were capped at 25 students and included additional prerequisite topics such graphing, factoring polynomials, and simplifying rational expressions.

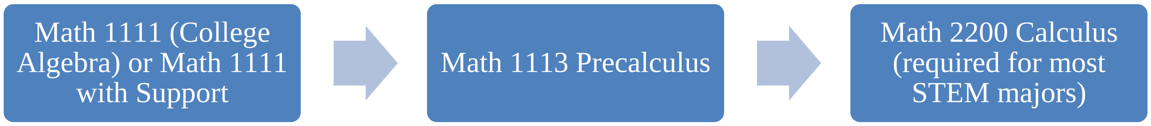

Figure 3.5 *Mathematics Course Sequence for STEM Majors*

Instruments

Demographic Questionnaire (Appendix A)

Students were asked to provide their gender, race/ethnicity, age, academic major, prior mathematics courses in college and high school, course section number, first-generation status, financial aid status, academic year, number of course credits enrolled in the current semester, their expected final grade, and level of enjoyment of mathematics. The demographic questionnaire and Belonging Scale were administered via Qualtrics.

Sense of Belonging Scale (Adapted from Good et al., 2012; Appendix B)

The primary instrument used in this study was a mathematics classroom sense of belonging scale, which I adapted from Good et al. (2012)'s Sense of Belonging to Math Scale. I selected this instrument because it was designed to measure students' feelings of membership and acceptance within the mathematics academic community, making it appropriate for examining belonging in college algebra and precalculus classrooms. The authors established internal validity through principal components analysis, which identified five reliable subscales: Membership, Acceptance, Affect, Trust, and Desire to Fade. The scale demonstrated high internal consistency (Cronbach's α=0.94), and the composite score was a strong predictor of students' intent to pursue mathematics beyond introductory courses. The original study sample consisted of calculus students at a highly selective university in the Northeastern U.S. Participants were 47% White, 3% Black, 21% Asian, 5% Latinx, and 25% other or unidentified.

The survey included 30 Likert-scale items (1=Strongly Disagree to 6=Strongly Agree). Responses were averaged to create composite belonging scores for pre-and post-surveys. The phrase "When I am in *a math setting*" was revised to "When I am in *my math class.*"

Data Collection Procedures

In both the pre- and post-surveys, students completed (1) a demographic questionnaire, and (2) an adapted version of the Sense of Belonging Scale (Good et al., 2012). (See Appendices A and B). Prior to completing the pre-survey, students were asked to review and sign an informed consent form. Informed consent forms were obtained from students aged 18 or older, and parent/guardian consent forms were obtained for students under the age of 18 (Appendix F). I requested permission from each college algebra and precalculus instructor to collect data from students in all sections. For my own college algebra sections in which I was the instructor, I asked a colleague to administer the surveys on my behalf.

Students completed surveys using their personal computers or cell phones via Qualtrics, accessed through a QR code displayed at the front of the classroom. Surveys were administered either at the beginning or end of class time for 15 minutes. I cleaned the data to remove incomplete responses. Only students who completed both pre-and post-surveys were included in the analysis of belonging change.

I used the following variables in the quantitative analysis:

- Pre-belonging score: Composite score at the beginning of the semester
- Post-belonging score: Composite score at the end of the semester
- Belonging difference score: Post-score minus Pre-score
- Faculty: Anonymized instructor identifier

- Mathematics affinity: Self-reported agreement to the statement "I enjoy learning and doing math."
- Expected course grade: Self-reported expected final grade

Quantitative Data Analysis

I analyzed the quantitative data using SPSS. All analyses used an alpha level of 0.05 to determine statistical significance. First, I used descriptive statistics and histograms to examine central tendencies and distributions of pre-, post-, and difference scores. To address Research Question 1, which focused on group comparisons, I conducted a one-way analysis of variance (ANOVA) on pre-belonging scores to test for mean differences across race-gender groups. Next, I conducted a multifactor analysis of covariance (ANCOVA) on post-belonging scores while controlling for pre-belonging scores, incorporating race×gender, faculty, post-mathematics affinity, and expected grades as factors in the model. To address Research Question 2, which examined belonging changes, I conducted a multifactor ANOVA including the same factors to examine belonging change. All statistical assumptions for each analysis were verified prior to conducting each analysis (Appendices G and H).

Phase 2: Qualitative Method

Context-bound and situated, qualitative research focuses on meaning-making, interpretation, and storytelling (Braun & Clarke, 2019). Qualitative research methods have been identified as appropriate for intersectional studies because they allow participants to introduce themes that the interviewer may not have anticipated (Charleston et al., 2014). This approach aligns with two key theoretical perspectives guiding this study: *intersectionality*, which centers students' lived experiences and voices, and *authorizing student perspectives*, which emphasizes the importance of hearing directly from students to understand their classroom experiences.

I collected two types of data in the qualitative phase: (a) mathematics autobiographies and (b) individual interviews. I selected these methods to explore participants' personal experiences with belonging as shaped by their intersectional identities and classroom contexts. By hearing directly from Black and Latina female students about how they experience belonging in mathematics courses, this phase provided the deeper understanding needed to explain the quantitative results in Phase 1.

Student Participants

I interviewed 13 participants (five Black female, two Black/Latina, and six Latina students), based on the quantitative data analyses. I purposefully selected participants from the quantitative data analysis to represent a range of belonging scores, including both positive and negative changes in belonging over the semester. All participants were 18 years of age or older, remained enrolled in their mathematics courses throughout the semester, and the majority were pursuing STEM majors. I recruited Black and Latina female students who completed both pre- and post-surveys through email invitations. The 13 participants were in different classes, except that Imani and Jess were in the same class. Alexa and Faith also had the same professor but were in different classes. The 13 participants were taught by 11 different faculty members. Table 3.2 presents detailed information for each of the 13 interview participants, including their race/ethnicity, enrolled mathematics course, pre- and post-belonging scores, change in belonging over the semester, and declared major.

Table 3.2 *Description of Qualitative Phase Participants*

Participant (Pseudonym)	Race/ Ethnicity	Course	Pre-belonging	Post-belonging	Post-Pre	Major
Alexa	Latina	College Algebra	4.37	4.97	+0.6	Nursing

Ana	Latina	College Algebra	4.77	2.57	-2.2	Applied Math-Engineering
Anela	Black/Latina	Precalculus	2.7	2.87	+0.17	Biology
Britteny	Black	College Algebra	5.87	6	+0.13	Biochemistry
Faith	Black	College Algebra	4.4	3.5	-0.9	Nursing
Imani	Black	College Algebra with Support	5.27	4.63	-0.63	Biology
Jess	Black	College Algebra with Support	2.87	3.8	+0.93	Biology
Joselyn	Latina	College Algebra	3.93	3.7	-0.23	Biology-Zoology
Julianna	Latina	College Algebra	3.83	3.1	-0.73	Film with Art Minor
Kayla	Latina	College Algebra	3.77	3.6	-0.17	Business Management
Leslie	Latina	Precalculus	5.13	5.97	+0.83	Applied Math
Marlina	Black/Latina	Precalculus	2.83	4.13	+1.3	Biology
Tyanna	Black	College Algebra	3.53	4.2	+0.67	Chemistry

Data Collection Procedures

Brief Mathematics Autobiography:

Because college mathematics success is connected to past educational experiences in K-12, I asked the interview participants to write a short mathematics autobiography before the interview meeting (adapted from Leyva, 2021; Appendix C). Eleven of the 13 participants wrote a short mathematics autobiography, describing the major experiences that promoted or discouraged their feelings of belonging in K-12 mathematics classes. In addition, I asked the participants to reflect on how their sense of belonging was influenced by relationships with their instructors, classroom structures, and interactions with their classmates. I read the mathematics autobiographies before the interviews took place and used the responses from the autobiographies to refine individual students' interview protocols.

Individual Interviews:

I conducted semi-structured individual interviews ranging from 41 to 84 minutes (with an average of 59 minutes) to gain further insight into the participants' experiences. Semi-structured individual interviews are useful tools for uncovering phenomena that cannot be directly observed and help researchers gain insight into complex social phenomena.

I conducted semi-structured interviews in person in my office or via Zoom using an interview protocol (Appendix D) that was informed by my literature review and theoretical perspectives. All interviews were conducted at the end of the Fall 2023 semester. Individual interview participants were compensated $15 for their time. I refined the interview questions through a first round of pilot testing during the Summer 2023 semester with two participants, and further refined the questions based on survey items and mathematics autobiographies during the Fall 2023 semester. Interview prompts included questions such as, "In what ways did you feel that you belonged in your math classroom?" and "Can you think of a specific example of a time in this class when you felt like you didn't belong?" Through students' responses, my goal was to understand how they experienced belonging and what contextual factors influenced their sense of belonging in their college algebra or precalculus class.

Qualitative Data Analysis

I audio-recorded all interviews and used a professional transcription service, GoTranscript, to have them transcribed by a person. Once I received the transcripts, I listened to the recordings and checked each transcript for accuracy, making edits as needed. For the analysis, I followed Braun and Clarke's (2022) six-phase thematic analysis approach: 1) data familiarization and writing familiarization notes, 2) systematic data coding, 3) generating initial themes from coded and collated data, 4) developing and reviewing themes, 5) refining, defining, and naming themes, and 6) writing the report. Braun and Clarke emphasized that their procedures are not meant to be followed rigidly; rather, the researcher can mix the phases together iteratively through reflective and thoughtful engagement with the data and analytic process. I was drawn to this approach for its flexibility as it can be used across a range of theoretical frameworks as well as with both deductive and inductive analytic approaches. Other advantages of thematic analysis are that it is accessible to novice qualitative researchers, it has the potential to provide a rich, organized, and detailed description of the data, and it can generate unanticipated insights.

In more recent publications, Braun and Clarke (2019, 2021) referred to their method as ‘reflexive thematic analysis,’ highlighting the importance of the researcher’s reflexive engagement with theory, data, and interpretation. The emphasis on reflexivity aligns with the principles of intersectionality, which calls for researchers to critically examine their own positionality. Esposito and Evans-Winters (2022) explained that reflexivity involves a conscientious effort to examine and reflect on one’s own personal biases, value system, cultural upbringing, motives, beliefs, experiences with unequal power relationships, and thought processes in relation to the research study. Similarly, reflexive thematic analysis values the researcher’s skill and centers the researcher’s subjectivity as a resource for knowledge production rather than a potential credibility threat. Researchers are always reading the data with assumptions and need to make sense of the data and understand the importance and meaning of identified patterns. Discussions of ‘saturation’ and ‘coding reliability’ are not aligned with the reflexive thematic analysis approach (Braun et al., 2022).

In reflexive thematic analysis, codes are analytic units that capture a single observation or facet of meaning, which is used to develop initial themes. The coding process is central to theme development and involves time and space to deeply reflect and immerse oneself in the data. In contrast to codes, themes are multi-faceted and capture multiple observations. They are the final outcomes of data coding and interpretive stories about the data in relation to the research question. Themes do not passively emerge from the data, nor are they discovered. Rather, they are actively constructed, generated, or developed by the researcher through the six phases of analysis. Braun and Clarke (2022) defined themes as patterns of shared meaning unified by a central concept.

In thematic analysis, themes can be identified using an inductive approach or a deductive approach (Braun & Clarke, 2006). I used both approaches as I wanted my analysis to be both data-driven and theory-driven (Brinkmann, 2014). To generate initial codes using MAXQDA, I created codes from the core ideas of my theoretical perspectives (sense of belonging and intersectionality) and created code names first before placing the data into them (Galman, 2013). Then I read through the transcripts with the framework in mind and searched for evidence of core elements of belonging and intersectionality. Additionally, I coded my data using an inductive approach, making code labels based on the qualitative data (interviews and mathematics autobiographies) without predefined categories by assigning one word or short phrases, as well as using in vivo coding using words or phrases from participants (de Farias et al., 2021).

I had major challenges with the initial coding process which resulted in 194 initial codes across all transcripts and mathematics autobiographies. Recognizing the need to reduce the number of codes in a meaningful and coherent way, I read through the codes multiple times and worked on grouping codes based on shared meaning, reducing them to 25 refined codes. I began by identifying codes that described the same aspects of participants' experiences using different words or small variations of the same concept. For example, "doesn't feel prepared for math class," "feels mathematically behind," and "doesn't understand anything" were grouped under a broader code of "confidence in understanding mathematics." Throughout this grouping process, I referred back to the original data excerpts to ensure that the codes accurately captured participants' experiences. I also used my theoretical perspectives of sense of belonging and intersectionality to guide decisions about which codes should be preserved. Through multiple rounds of review, I refined these codes into two major themes, each with six subthemes: factors that positively influence sense of belonging and factors that negatively influence sense of belonging in mathematics classes.

To document the analytic process, I maintained a research memo in a Word document. This also served as a space to record coding decisions, reflections, challenges, wonderings, frustrations, and emerging insights. Research memos are important to ensure that ideas, changes, and reflections do not get lost because they might later prove to be significant (Birks et al., 2008). They helped me overcome "analytic paralysis" and move from data collection to data analysis, which was one of my biggest hurdles in the dissertation writing process.

Throughout the analysis, I dedicated substantial time to deeply reflect on and immerse myself in the data, which is consistent with the reflexive thematic analysis approach. To enhance the credibility of the findings, I maintained detailed research memos throughout the analysis process, engaged in regular discussions with my dissertation advisor about emerging themes, and used extensive participant quotes to support interpretations. The following chapter presents the quantitative results from Phase 1 of the study, which addresses Research Questions 1 and 2.

CHAPTER 4

QUANTITATIVE RESULTS

In this chapter, I present the findings from the quantitative phase of my mixed methods study addressing my first and second sub-questions:

1. How do Black and Latina female students' sense of belonging in the college algebra and precalculus classrooms compare to students in other racial and gender groups?
2. How does Black and Latina female students' sense of belonging in college algebra and precalculus change from the beginning to the end of the semester?

To answer these research questions, I analyzed the data using descriptive statistics, analysis of variance (ANOVA) for pre-belonging and belonging difference scores, and analysis of covariance (ANCOVA) for post-belonging scores while controlling for pre-belonging. I present the descriptive statistics first, followed by analyses of pre-belonging scores, post-belonging scores, and changes in belonging over the semester.

Descriptive Statistics

Descriptive statistics (Table 4.1) indicated that the overall mean pre-belonging score (*M*=4.432, *SD*=0.68) was almost identical to the mean post-belonging score (*M*=4.429, *SD*=0.77), with a slightly higher variability at the end of the semester. This is reflected in the mean belonging difference score which was close to 0 (*M*=-0.01, *SD*=0.57). There was a large drop between the number of students who completed the pre-belonging survey (N=1,136) and post-belonging survey (N=639). The relatively high mean scores on both pre and post surveys (on the belonging scale where 1=strongly disagree to 6=strongly agree) suggest that students who completed the semester (or chose to complete both surveys) maintained relatively high sense of belonging in their mathematics classes throughout the semester.

Table 4.1 *Mean and Standard Deviation of Pre-belonging, Post-belonging, and Belonging Difference Scores*

	N	Mean	Std. Deviation
Pre_belongingscore	1136	4.4322	.68087
Post_belongingscore	639	4.4285	.77320
BelongingDifference	631	-.0136	.56993

Variable Distributions

I examined the variable distributions for pre-belonging, post-belonging, and belonging difference using histograms (Figures 4.1, 4.2, 4.3). Pre-belonging scores (*M*=4.51, *SD*=0.68, N=1154) were mostly clustered between 4.0 and 5.0 (on a 6-point scale), with a relatively normal distribution. Post-belonging scores (*M*=4.43, *SD*=0.77, N=639) displayed greater variability with a slight left skew. The distribution of belonging difference scores (*M*=-0.0136, *SD*=0.57, N=631) was approximately normal and centered around 0, with most values falling between -1 and 1. This indicates that there was minimal average change in students' sense of belonging over the over the semester.

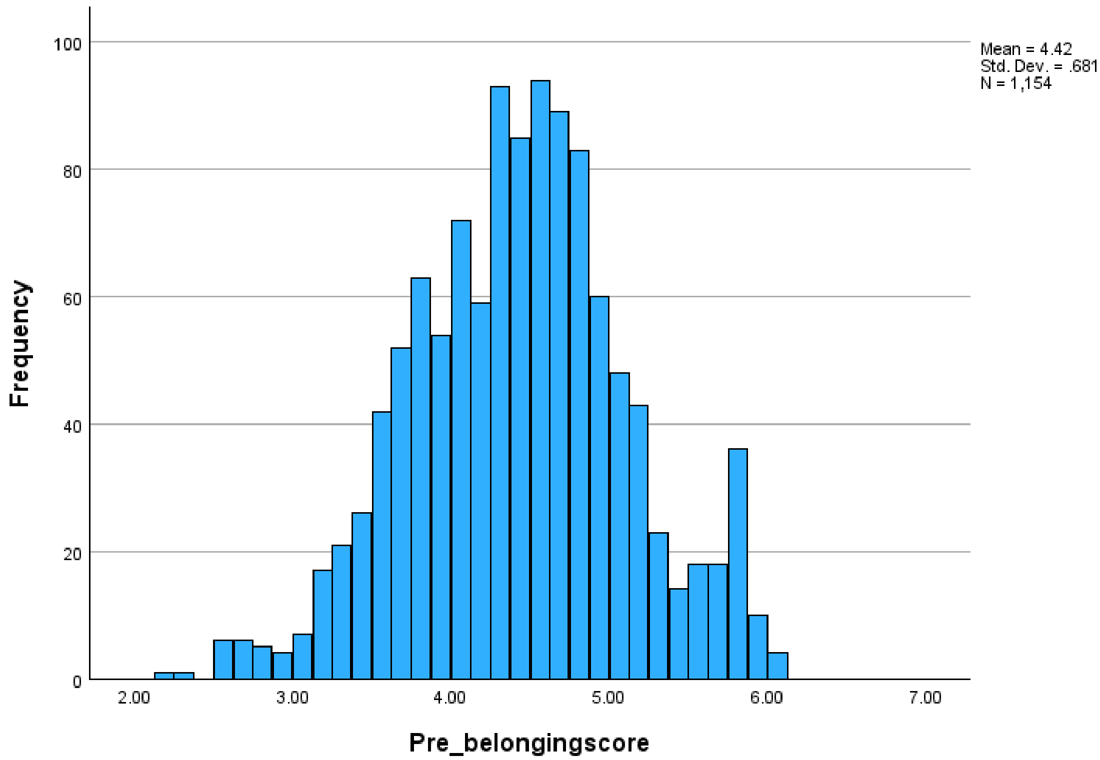

Figure 4.1 *Histogram of Pre-belonging Scores (N = 1,154)*

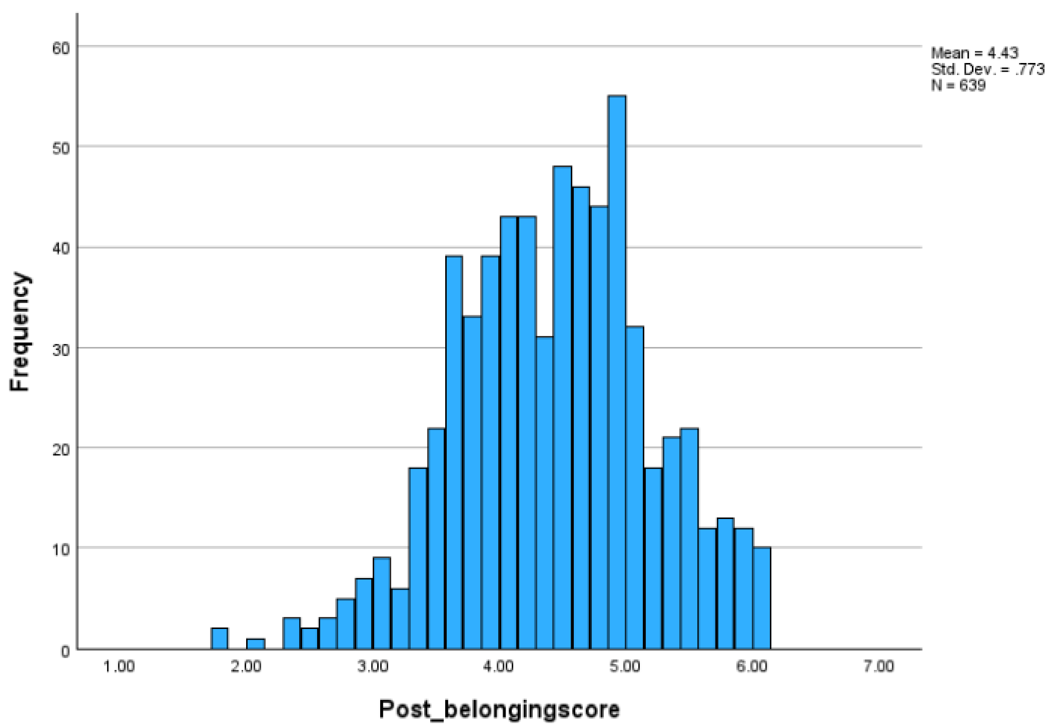

Figure 4.2 Histogram of Post-belonging Scores (N = 639)

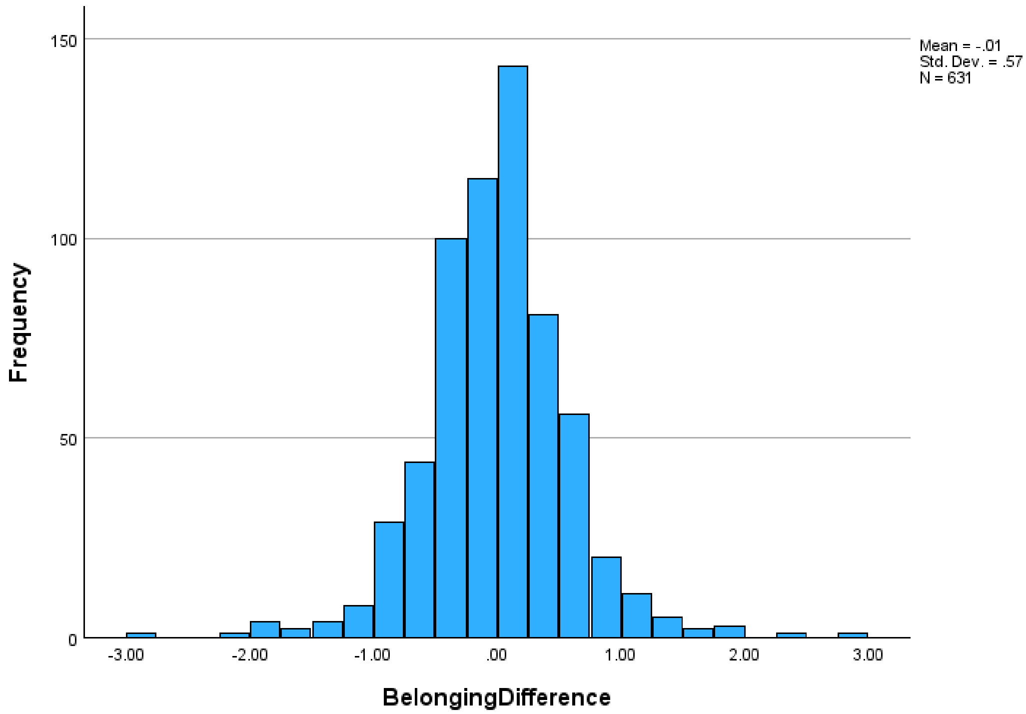

Figure 4.3 *Histogram of Belonging Difference Scores (N = 631)*

Pre-belonging Differences (ANOVA)

To address the first research question comparing Black and Latina female students' sense of belonging to other racial and gender groups, I conducted a one-way ANOVA on pre-belonging scores. Table 4.2 presents the descriptive statistics by racial and gender groups, while Figure 4.4 displays corresponding boxplots. All groups reported relatively high belonging scores on the 6-point scale, close to the overall mean. Black female students (*M*=4.40, *SD*=0.71), and Latina students (*M*=4.37, *SD*=0.69) reported pre-belonging scores slightly below the overall mean, although the difference is minimal. Black male students reported the highest pre-belonging scores (*M*=4.61, *SD*=0.65), while Asian/American male students reported the lowest (*M*=4.31, *SD*=0.63).

The one-way ANOVA revealed a statistically significant difference in pre-belonging scores among racial and gender groups (*p*=0.014, Table 4.3). I examined pairwise comparisons between race×gender groups (Table 4.4) and identified only one statistically significant group difference: Latina students reported lower pre-belonging scores than Black male students (p = 0.026, Mean Difference =-0.24). All other pairwise comparisons were not significant ($p > 0.05$), suggesting minimal variation in pre-belonging scores across groups at the beginning of the semester. I checked the assumptions for one-way ANOVA prior to analysis and found no major violations (Appendix G).

Table 4.2 *Descriptive Statistics for Pre-Belonging Scores by Race and Gender*

Pre_belongingscore

Gender	Race/Ethnicity	Mean	Std. Deviation	N
Female	Asian/Asian American	4.5160	.65747	77
	Black/African American	4.3964	.71374	184
	Hispanic/Latinx	4.3669	.69465	192
	White	4.4012	.69905	113
	Other	4.6101	.75968	23
	Total	4.4117	.69968	589
Male	Asian/Asian American	4.3100	.62984	74
	Black/African American	4.6088	.64746	167
	Hispanic/Latinx	4.3732	.65796	154
	White	4.4160	.67911	123
	Other	4.5273	.59372	29
	Total	4.4544	.65994	547
Total	Asian/Asian American	4.4151	.65019	151
	Black/African American	4.4975	.69026	351
	Hispanic/Latinx	4.3697	.67760	346
	White	4.4089	.68730	236
	Other	4.5639	.66649	52
	Total	4.4322	.68087	1136

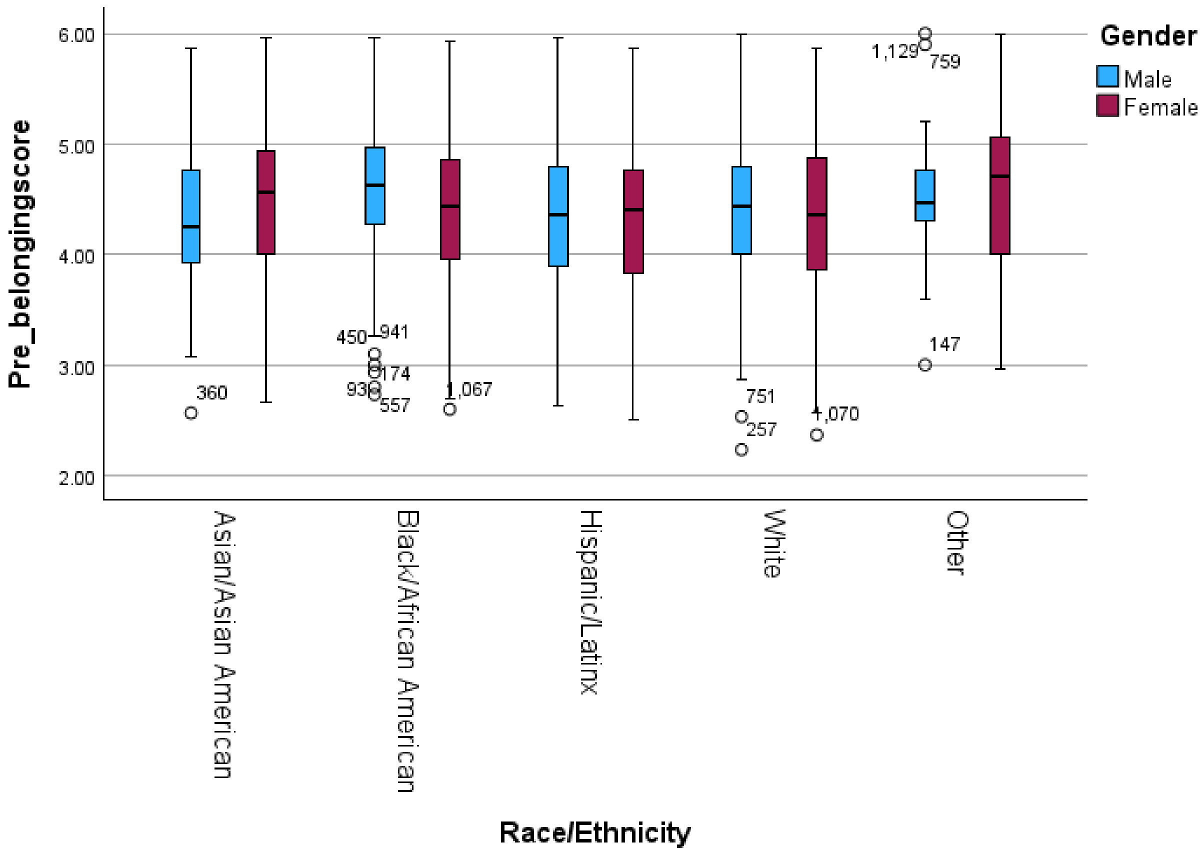

Figure 4.4 *Box Plot of Pre-belonging Scores Based on Race and Gender*

Table 4.3 *ANOVA Summary Table for Group Differences in Pre-Belonging by Race and Gender*

Tests of Between-Subjects Effects

Dependent Variable: Pre_belongingscore

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9.578[a]	9	1.064	2.320	.014	.018
Intercept	13713.902	1	13713.902	29892.133	<.001	.964
genderxrace	9.578	9	1.064	2.320	**.014**	.018
Error	516.586	1126	.459			
Total	22842.607	1136				
Corrected Total	526.164	1135				

a. R Squared = .018 (Adjusted R Squared = .010)

Table 4.4 *Multiple Comparisons Between Groups for Pre-Belonging by Race and Gender*

(I) Race×Gender	(J) Race×Gender	Mean Difference (I-J)	Std. Error	Sig.
Female_Asian/American	Female_Black	.11958	.09193	.954
	Female_Hispanic	.14914	.09137	.832
	Female_White	.11484	.10009	.980
	Female_Other	-.09413	.16095	1.000
	Male_Asian/American	.20598	.11026	.691
	Male_Black	-.09280	.09330	.993
	Male_Hispanic	.14286	.09454	.888
	Male_White	.10003	.09843	.991
	Male_Other	-.01129	.14757	1.000
Female_Black	Female_Asian/American	-.11958	.09193	.954
	Female_Hispanic	.02955	.06988	1.000
	Female_White	-.00475	.08095	1.000
	Female_Other	-.21371	.14980	.919
	Male_Asian/American	.08640	.09324	.996
	Male_Black	-.21238	.07239	.098
	Male_Hispanic	.02327	.07398	1.000
	Male_White	-.01956	.07889	1.000
	Male_Other	-.13088	.13533	.994
Female_Hispanic	Female_Asian/American	-.14914	.09137	.832
	Female_Black	-.02955	.06988	1.000
	Female_White	-.03430	.08031	1.000
	Female_Other	-.24326	.14945	.835
	Male_Asian/American	.05685	.09268	1.000
	Male_Black	-.24193*	.07167	**.026**
	Male_Hispanic	-.00628	.07327	1.000
	Male_White	-.04911	.07823	1.000
	Male_Other	-.16043	.13494	.974

Female_White	Female_Asian/American	-.11484	.10009	.980
	Female_Black	.00475	.08095	1.000
	Female_Hispanic	.03430	.08031	1.000
	Female_Other	-.20896	.15494	.942
	Male_Asian/American	.09115	.10129	.996
	Male_Black	-.20764	.08251	.261
	Male_Hispanic	.02802	.08390	1.000
	Male_White	-.01481	.08826	1.000
	Male_Other	-.12613	.14100	.997
Female_Other	Female_Asian/American	.09413	.16095	1.000
	Female_Black	.21371	.14980	.919
	Female_Hispanic	.24326	.14945	.835
	Female_White	.20896	.15494	.942
	Male_Asian/American	.30011	.16170	.699
	Male_Black	.00133	.15065	1.000
	Male_Hispanic	.23698	.15141	.865
	Male_White	.19416	.15387	.962

Post-belonging Differences (ANCOVA)

To address research question 1, I also examined post-belonging scores across racial and gender groups by conducting a multifactor Analysis of Covariance (ANCOVA) while controlling for pre-belonging scores. Table 4.5 and Figure 4.5 display the descriptive statistics and boxplots of post-belonging scores respectively by race and gender. Female students reported slightly higher post-belonging scores than male students. Among male students, Black students reported the highest mean scores (*M*=4.56, *SD*=0.71), while Asian/American students reported the lowest (*M*=4.30, *SD*=0.75). For female students, Asian/American students had the highest mean scores (*M*=4.51, *SD*=0.80), while Latina students had the lowest (*M*=4.40, *SD*=, 0.77). Overall, post-belonging scores remained relatively consistent, ranging between 4.30 and 4.56 on the 6-point scale.

I incorporated multiple factors in the ANCOVA model (Table 4.6) informed by qualitative analyses: race×gender, faculty, post-mathematics affinity, and post-expected grade (with rationale provided in the Discussion chapter). The overall model was statistically significant ($p < 0.001$) and explained a large portion of the variance in post-belonging scores ($R^2 = 0.617$, adjusted $R^2 = 0.584$). Pre-belonging ($p < 0.001$), post-mathematics affinity ($p < 0.001$) and post-expected grade ($p < 0.001$) were all statistically significant contributors to post-belonging. In contrast, faculty ($p = 0.138$) and race×gender ($p = 0.740$) did not significantly influence post-belonging scores. For post-belonging, these findings suggest that students' self-reported mathematics affinity and final grade expectations (which may be related to mathematics self-efficacy) were more associated with end of semester belonging rather than race/gender and faculty. All ANCOVA assumptions were checked prior to analysis (Appendix H).

Table 4.5 *Descriptive Statistics for Post-Belonging Scores by Gender and Race*

Post_belongingscore

Gender	Race/Ethnicity	Mean	Std. Deviation	N
Female	Asian/Asian American	4.5089	.80420	42
	Black/African American	4.4939	.76304	87
	Hispanic/Latinx	4.3993	.77237	111
	White	4.4044	.83895	68
	Other	4.4319	.86397	14
	Total	4.4416	.78893	322
Male	Asian/Asian American	4.2971	.75030	49
	Black/African American	4.5634	.70761	99
	Hispanic/Latinx	4.3209	.74593	83
	White	4.4159	.80778	67
	Other	4.3563	.85206	19

	Total	4.4151	.75790	317
Total	Asian/Asian American	4.3948	.77855	91
	Black/African American	4.5309	.73287	186
	Hispanic/Latinx	4.3657	.76021	194
	White	4.4101	.82057	135
	Other	4.3884	.84443	33
	Total	4.4285	.77320	639

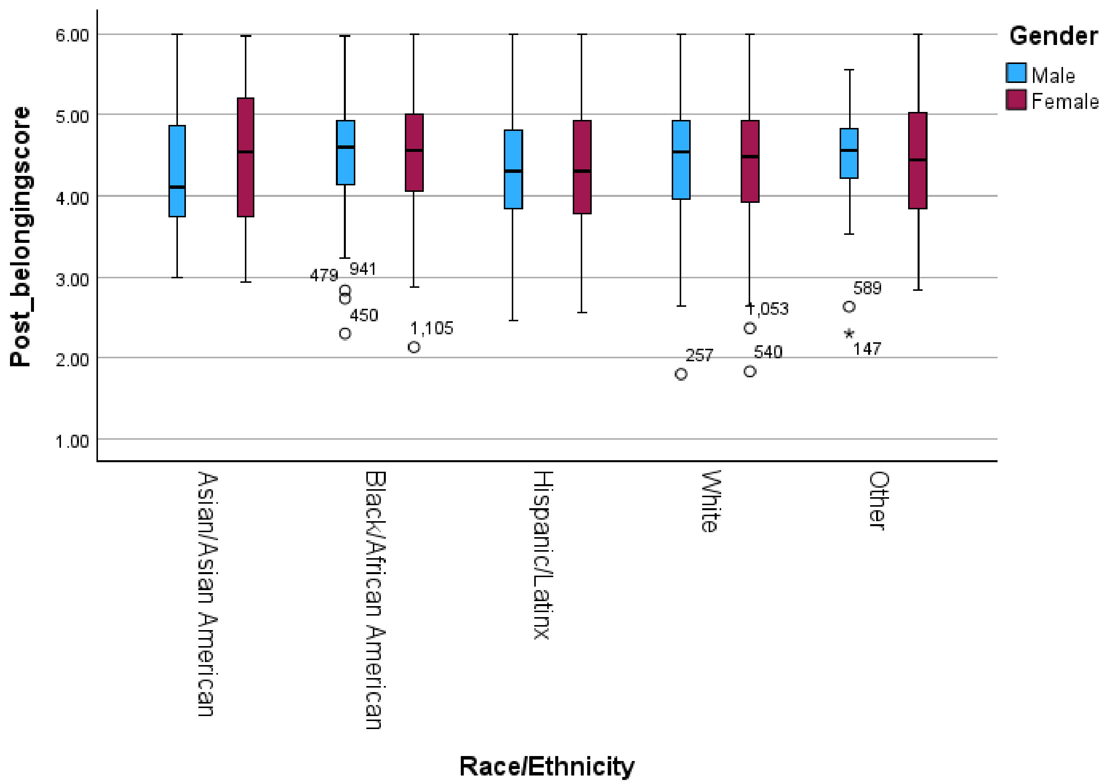

Figure 4.5 *Box Plot of Post-belonging Scores Based on Race and Gender*

Table 4.6 *ANCOVA Summary Table for Post-belonging scores by Pre-belonging, Gender×Race, Faculty, Mathematics Affinity, and Expected Grade*

Tests of Between-Subjects Effects

Dependent Variable: Post_belongingscore

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	232.881[a]	50	4.658	18.532	<.001	.617
Intercept	13.494	1	13.494	53.691	<.001	.085
Pre_belongingscore	113.163	1	113.163	450.249	**<.001**	.439
genderxrace	1.506	9	.167	.666	.740	.010
Faculty	10.341	32	.323	1.286	.138	.067
post_mathaffinity	11.755	4	2.939	11.693	**<.001**	.075
post_expected_grade	6.864	4	1.716	6.828	**<.001**	.045
Error	144.518	575	.251			
Total	12654.876	626				
Corrected Total	377.399	625				

a. R Squared = .617 (Adjusted R Squared = .584)

Belonging Change (Difference Score ANOVA)

To address both research questions regarding the differences and changes in belonging for Black and Latina female students, I analyzed belonging differences scores (post-belonging minus pre-belonging) using a multi-factor analysis of variance (ANOVA). Descriptive statistics (Table 4.7) and boxplots (Figure 4.6) show relatively minor differences in belonging across all gender and racial groups. Female students showed a slight positive average change (*M*=0.0124, *SD*=0.62, n=319), with White female students having the highest positive difference (*M*=0.0631, *SD*=0.69, n=67) and Latina students the lowest (*M* 0.0377, *SD*=0.51, n=110). Male students reported a small negative average change (*M*=-0.0403, *SD*=0.51, n=312), with White male students showing the least negative change (*M* =0.02, *SD*=0.54, n=67) and students in the "Other" race category reporting the largest decrease (*M*=-0.2378, *SD*=0.64, n=19).

The multi-factor ANOVA model included race×gender interaction, Faculty, post-mathematics affinity, and expected course grade as factors (Table 4.8). The overall model was statistically significant ($p < 0.001$) and explained approximately 18.2% of the variance in belonging difference scores ($R^2 = 0.182$, Adjusted $R^2 = 0.112$). The effect of race×gender was not significant ($p = 0.541$), suggesting that changes in belonging did not significantly differ across race and gender groups. However, faculty was a statistically significant factor ($p = 0.034$), suggesting that faculty have an influence on belonging changes. Moreover, both the factors post-mathematics affinity ($p < 0.001$) and post-expected grade ($p = 0.012$) were statistically significant, indicating students who reported higher mathematics affinity and expected higher grades (possible indicators of mathematics self-efficacy) were more likely to report positive belonging changes throughout the semester. All ANOVA assumptions were checked prior to analysis (Appendix I).

Table 4.7 *Descriptive Statistics for Belonging Difference Scores by Race and Gender*

BelongingDifference

Gender	Race/Ethnicity	Mean	Std. Deviation	N
Female	Asian/Asian American	.0590	.68519	42
	Black/African American	.0249	.67940	86
	Hispanic/Latinx	-.0377	.50760	110
	White	.0631	.69153	67
	Other	-.0538	.55982	14
	Total	.0124	.62147	319
Male	Asian/Asian American	.0257	.44445	47
	Black/African American	-.0611	.49162	96
	Hispanic/Latinx	-.0570	.50875	83
	White	.0200	.54286	67
	Other	-.2378	.64146	19
	Total	-.0403	.51154	312
Total	Asian/Asian American	.0414	.56769	89

	Black/African American	-.0205	.58777	182
	Hispanic/Latinx	-.0460	.50686	193
	White	.0416	.61969	134
	Other	-.1597	.60606	33
	Total	-.0136	.56993	631

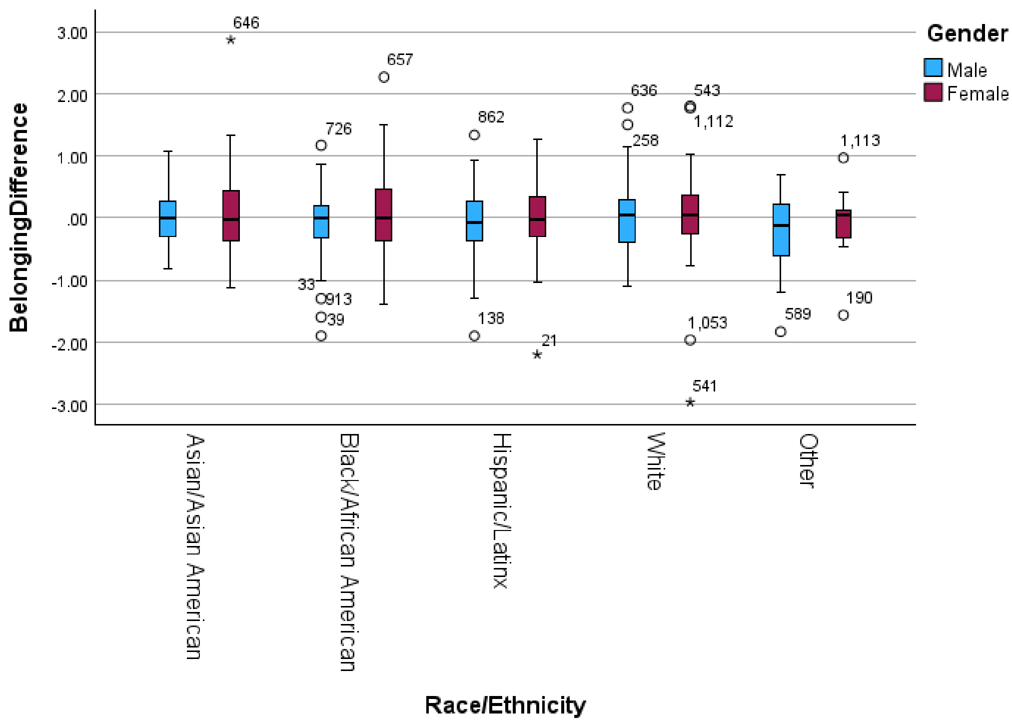

Figure 4.6 *Boxplot of Belonging Difference Scores by Race and Gender*

Table 4.8 *ANOVA Summary Table for Belonging Difference Scores by Gender×Race, Faculty, Mathematics Affinity, and Expected Grade*

Tests of Between-Subjects Effects

Dependent Variable: BelongingDifference

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	37.025[a]	49	.756	2.607	<.001	.182
Intercept	1.917	1	1.917	6.615	.010	.011

genderxrace	2.300	9	.256	.882	.541	.014
Faculty	14.164	32	.443	1.527	**.034**	.078
post_mathaffinity	8.719	4	2.180	7.521	**<.001**	.050
post_expected_grade	3.775	4	.944	3.256	**.012**	.022
Error	166.947	576	.290			
Total	204.067	626				
Corrected Total	203.972	625				

a. R Squared = .182 (Adjusted R Squared = .112)

Summary of Research Question Findings

RQ1: How do Black and Latina female students' sense of belonging in the college algebra and precalculus classrooms differ compared to students in other racial and gender groups?

The quantitative results indicate that Black and Latina female students' mean belonging scores were comparable to other racial and gender groups. At the beginning of the semester only Latina female students showed a statistically significant difference, reporting lower belonging than Black male students (p = 0.026, Mean Difference =-0.24). Black female students' mean belonging scores were not significantly different from any other group. By the end of the semester, when controlling for pre-belonging scores, race×gender was not a significant factor in post-belonging (p =0.740), indicating no significant differences between Black and Latina female students and other groups.

RQ2: How does Black and Latina female students' sense of belonging in college algebra and precalculus change from the beginning to the end of the semester?

Analysis of belonging change scores revealed no significant differences based on race×gender (p = 0.541). Black and Latina female students did not have significantly different changes in belonging compared to other groups throughout the semester. Instead, belonging changes were associated with faculty (p=0.034), mathematics affinity (p<0.001), and expected course grades (p=0.012).

Summary

In this chapter, I presented the quantitative results examining sense of belonging among Black and Latina female students in college algebra and precalculus classrooms. The analyses showed that students maintained relatively stable and high belonging scores throughout the semester, with minimal average change. For pre-belonging scores, while there was a statistically significant difference between two groups, only Latina female students reported significantly lower pre-belonging scores than Black male students. The ANCOVA for post-belonging revealed that race×gender (p = 0.740) and faculty (p = 0.138) did not significantly affect end of semester belonging when controlling for pre-belonging. However, students' mathematics affinity (p<0.001) and expected course grades (p<0.001) were significant factors on post-belonging.

While faculty did not significantly impact post-belonging scores, faculty did significantly influence changes in belonging over the semester. This suggests that instructors play an important role in how students' belonging changes throughout the semester. Race and gender interaction was not significant for both post-belonging and belonging difference scores, indicating that at this institution, students' end of semester belonging scores and belonging changes did not significantly differ across racial and gender groups.

These quantitative findings from the first phase of this sequential explanatory mixed methods study provide a foundation for the following qualitative findings chapter, where I explore Black and Latina female students' belonging experiences through interviews and mathematics autobiographies. Following the mixed methods design, the qualitative phase will help explain and expand upon the quantitative results, informing how mathematics professors' pedagogical approaches, classroom dynamics, peer connections, students' mathematics self-efficacy, and perceptions of diversity interact to support or hinder belonging in undergraduate mathematics classrooms.

CHAPTER 5

QUALITATIVE FINDINGS

In this chapter, I present the qualitative findings from interview transcripts of 13 participants and the mathematics autobiographies of 11 participants. This second qualitative phase addressed my third research question: How do Black and Latina female students describe their college algebra and precalculus learning environment, experiences, participation, persistence, support systems, and challenges as it relates to their sense of belonging? First, I discuss participants' collective definition of sense of belonging in mathematics classroom based on their mathematics autobiography responses. Then, I explore six factors that positively influence sense of belonging, which include: (1) professor's mathematical microaffirmations, (2) students' perception of their professor as caring, supportive, and helpful, (3) professors encouraging peer collaboration in class, (4) connection with class peers, (5) positive mathematics self-efficacy and (6) perception of classroom diversity. Next, I examine six factors that negatively influence students' sense of belonging: (1) professor's mathematical microaggressions, (2) students' perceptions of professor as uncaring, unsupportive, or unhelpful, (3) limited peer collaboration in class (4) lack of peer connection, (5) negative mathematics self-efficacy, and (6) past negative mathematics class experiences. These findings highlight the complex dynamics of factors that shape Black and Latina female students' sense of belonging in mathematics classrooms and provide critical insights for fostering belonging in these spaces.

Students' Collective Definition of Sense of Belonging in the Mathematics Classroom

One of my theoretical perspectives is Cook-Sather's (2002) notion of *authorizing student perspectives*, which centers and recognizes students as having essential knowledge of what is happening in classrooms firsthand. To understand how the participants experience and define sense of belonging in mathematics classrooms, I included the following question on the mathematics autobiography: 'How would you define belonging?' Out of 13 participants, 11 students responded to the question. Using their responses and own words, I constructed the following collective definition of students' sense of belonging in a mathematics class:

> Belonging is when students feel comfortable, recognized, important, validated, welcome, included, peaceful, valued, important, and supported in the class, knowing they have a purpose there beyond themselves without second-guessing their presence. It is about being their authentic selves while being around a diverse group of peers who accept and respect one another. In mathematics classrooms, belonging develops when everyone shares a common purpose, works together, helps each other understand mathematical concepts, and is provided with equitable opportunities to succeed, regardless of their gender, racial, ethnic, social, or academic background.

This student-derived definition of belonging encompasses Cook-Sather's perspective by validating participant's lived experiences and recognizing them as authorities on their own perception of belonging in mathematics classrooms.

There are similarities and differences between the students' definition of belonging and Strayhorn's (2019) definition, "Sense of belonging refers to students' perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the campus community or others on campus such as faculty, staff, and peers" (p.4). Both definitions emphasize the importance of interpersonal connections such as feeling accepted, respected, valued, and important among faculty and peers. However, the students' definition adds 'authenticity' as an important component of belonging, to be able to be their true selves while being accepted by peers. While Strayhorn's definition focuses on the campus community, the students' definition situates belonging within mathematics classrooms. Moreover, the students' definition considers the conditions that foster belonging in mathematics classrooms (collaborative learning and peer support) and encompasses students' desires for equitable opportunities for success. In the next section, I will discuss factors that promote students' sense of belonging in mathematics.

Factors that Positively Influence Sense of Belonging in Mathematics Class

Through my qualitative data analysis, I identified six factors that promote a sense of belonging in a diverse introductory mathematics classes: (1) professor's mathematical microaffirmations, (2) students' perception of their professor as caring, supportive, and helpful, (3) professor's encouraged peer collaboration in class, (4) connections with class peers, (5) high mathematics self-efficacy, and (6) perception of classroom diversity. In the following section, I describe each factor and provide supporting evidence from participant interviews and mathematics autobiographies. To protect their gender identities, all professors are referred to as "they/them/their" pronouns.

In Table 5.1 below, I have organized participants in descending order based on the change between their pre-belonging and post-belonging scores (highest to lowest change). In Table 5.2, participants are arranged according to their post-belonging scores, from highest to lowest. For both tables, I have used checkmarks (✓) to indicate each student's experience with the six factors that positively influence students' sense of belonging in introductory mathematics classrooms.

Table 5.1 *Participant's Belonging Scores and Positive Factors on Belonging, Listed in Order of Change in Belonging Score (Highest to Lowest)*

Students in decreasing order of change in belonging score	Pre-belonging score 1-6 (Z-score)	Post-belonging score 1-6 (Z-score)	Post-Pre (SD)	Professor			Class Peer Connection	Positive Mathematics Self-Efficacy	Perception of Classroom Diversity
				Mathematical Microaffirmations	Caring, Supportive, and Helpful	Encouraged Peer Collaboration			
Marlina	2.83 (-2.33)	4.13 (-0.39)	**+1.3** (>2SD)	✓	✓		✓	✓	
Jess	2.87 (-2.28)	3.8 (-0.82)	**+0.93** (>1SD)	✓	✓	✓			✓
Leslie	5.13 (1.04)	5.97 (1.99)	**+0.83** (>1SD)		✓	✓	✓ (multiple)	✓	
Tyanna	3.53 (-1.31)	4.2 (-0.30)	**+0.67** (>1SD)	✓	✓			✓	✓
Alexa	4.37 (-0.07)	4.97 (0.70)	**+0.6** (>1SD)	✓	✓	✓	✓ (multiple)	✓	✓
Anela	2.7 (-2.53)	2.87 (-2.02)	**+0.17** (<1SD)				✓		
Britteny	5.87 (2.13)	6 (2.03)	**+0.13** (<1SD)	✓	✓	✓	✓ (multiple)		✓
Kayla	3.77 (-0.95)	3.6 (-1.07)	**-0.17** (<1SD)						
Joselyn	3.93 (-0.72)	3.7 (-0.94)	**-0.23** (<1SD)				✓		
Imani	5.27 (1.25)	4.63 (0.26)	**-0.63** (>1SD)		✓	✓			
Julianna	3.83 (-0.87)	3.1 (-1.72)	**-0.73** (>1SD)		✓				
Faith	4.4 (-0.03)	3.5 (-1.20)	**-0.9** (>1SD)	✓	✓	✓			
Ana	4.77 (0.51)	2.57 (-2.41)	**-2.2** (>3SD)						✓

Table 5.2 *Participant's Belonging Scores and Positive Factors on Belonging, Listed in Order of Post-Belonging Score (Highest to Lowest)*

Students in decreasing order of post-belonging score	Pre-belonging score 1-6 (Z-score)	Post-belonging score 1-6 (Z-score)	Post-Pre (SD)	Professor			Class Peer Connection	Positive Mathematics Self-Efficacy	Perception of Classroom Diversity
				Mathematical Microaffirmations	Caring, Supportive, and Helpful	Encouraged Peer Collaboration			
Britteny	5.87 (2.13)	6 (2.03)	+0.13 (<1SD)	✓	✓	✓	✓ (multiple)		✓
Leslie	5.13 (1.04)	5.97 (1.99)	+0.83 (>1SD)		✓	✓	✓ (multiple)	✓	
Alexa	4.37 (-0.07)	4.97 (0.70)	+0.6 (>1SD)	✓	✓	✓	✓ (multiple)	✓	✓
Imani	5.27	4.63	-0.63		✓	✓			

	(1.25)	(0.26)	(>1SD)						
Tyanna	3.53 (-1.31)	4.2 (-0.30)	+0.67 (>1SD)	✓	✓			✓	✓
Marlina	2.83 (-2.33)	4.13 (-0.39)	+1.3 (>2SD)	✓	✓		✓	✓	
Jess	2.87 (-2.28)	3.8 (-0.82)	+0.93 (>1SD)	✓	✓	✓			✓
Joselyn	3.93 (-0.72)	3.7 (-0.94)	-0.23 (<1SD)				✓		
Kayla	3.77 (-0.95)	3.6 (-1.07)	-0.17 (<1SD)						
Faith	4.4 (-0.03)	3.5 (-1.20)	-0.9 (>1SD)	✓	✓	✓			
Julianna	3.83 (-0.87)	3.1 (-1.72)	-0.73 (>1SD)		✓				
Anela	2.7 (-2.53)	2.87 (-2.02)	+0.17 (<1SD)				✓		
Ana	4.77 (0.51)	2.57 (-2.41)	-2.2 (>3SD)						✓

Professor’s Mathematical Microaffirmations

Professors have significant influence in making students feel included and valued in the classroom. Research indicates that positive acknowledgement from educators and peers can impact students’ sense of belonging (Barbieri & Miller-Cotto, 2021). One particularly effective practice for promoting belonging is the use of microaffirmations, which are brief acts that communicate care and support (Demetriou et al., 2023). Cawley & Wilson (2023) defined mathematical affirmations as “subtle actions that can support students by affirming that they belong in mathematics” (p. 3). These acts communicate to students that instructors believe in their mathematical abilities and value their efforts and contributions, including their “wrong answers” and “misconceptions.” These small gestures become powerful when they come from instructors and more authentic when tailored to individuals rather than addressed to the entire class. Importantly, Cawley and Wilson (2023) caution that instructors must use microaffirmations thoughtfully, as they can potentially be perceived as microaggressions or used inequitably based on patterns of race, gender, or ability. Nevertheless, as participants in this study shared, mathematical microaffirmations can positively influence students' sense of belonging in mathematics classes.

Of the 13 participants, five students (Alexa, Britteny, Jess, Marlina and Tyanna) described receiving mathematical microaffirmation from their mathematics professor. Four of these students' (Alexa, Jess, Marlina, and Tyanna) belonging score increased more than one standard deviation over the semester, while one student's (Britteny) belonging score remained high from beginning to end. Among the five students whose belonging score increased more than one standard deviation, only one student (Leslie) did not report experiencing a mathematical microaffirmation.

Notably, of the five students who experienced mathematical microaffirmations, four (Alexa, Britteny, Jess, and Tyanna) participants did not report encountering mathematical microaggressions in their classes. The absence of mathematical microaggressions represents a significant commonality among these participants and aligns with research suggesting that mathematical microaggressions negatively impact students' sense of belonging (Cawley & Wilson, 2023; Cawley et al., 2023; Su, 2015).

The data suggests that avoiding mathematical microaggressions may be as powerful for increasing (or maintaining) belonging as actively using mathematical microaffirmations. For example, in her mathematics autobiography, Ana shared that she feels accepted and valued in mathematics classrooms when teachers avoid phrases such as, "everyone should know this," because such statements make her "feel dumb or like I have fallen behind." I expand on students' experiences with mathematical microaggressions in the next section addressing factors that negatively impact sense of belonging in mathematics classrooms.

Participants characterized mathematical microaffirmations as recognition of their work and effort from professors. Alexa felt valued when her professor reviewed her work and affirmed, “You’re doing this perfectly, this is exactly how you’re supposed to do it.” This validation made her feel confident that “I know what I’m doing, and all of this is doable.” Similarly, Marlina described a time when she struggled with a problem in class, and her professor asked her to explain her thinking. After Marlina explanation, her professor responded, “Yes, exactly, you’re on the right track… good job, Marlina.” She shared that these brief interactions made her feel “really good.” Additionally, Marlina’s professor would invite her to demonstrate her work on the board, which felt confirming that what she was doing was right. After several classes, Marlina began to believe, “I’m getting it, I can do this, so that was a good turning point for me.” Jess explained that although she had the hardest time with certain concepts, her professor acknowledged her improvement and “gave her words of encouragement.” For Alexa, Marlina, and Jess, professors’ mathematical microaffirmations made them feel capable of success in the class, strengthening their mathematics self-efficacy, which in turn enhanced their sense of belonging.

Britteny described experiencing mathematical microaffirmations in the form of encouragement. She recalled that her professor saying, “Don’t stress yourself, it’s all a lot to take in. Just take it step by step.” This supportive approach had a positive impact on her: “It’s encouraging me that I don’t have to, I won’t always know everything. You have to take things step by step before you can understand.” Although this mathematical microaffirmation was addressed to the entire class, Britteny felt reassured that it was acceptable not to understand everything immediately and that learning is a gradual process.

Tyanna's experience of mathematical microaffirmation involved her professor taking the time to listen and validate her experiences. During a test, anxiety made Tyanna feel sick, causing her to submit the test early. She explained, "I really beat myself up over that because that was my favorite unit, and I just didn't get a chance to show that I knew it. I know how to do the work, and I had good grades, but it was really bringing my test grades down." After Tyanna emailed her professor about her anxiety, they responded with support and encouragement. Her professor shared that taking exams used to make them nervous too and offered strategies for managing test anxiety. Tyanna appreciated that her professor "took the extra step to not let me feel like I couldn't do well… I felt seen." This validation of Tyanna's anxiety and struggles conveyed that she mattered in class, strengthening her sense of belonging.

Although most mathematical microaffirmations came from students' professors, others outside the classroom, such as tutors or class peers, also provided valuable microaffirmations. Tyanna was among the few participants who mentioned using the college's tutoring center. She noted that the mathematics tutors significantly bolstered her confidence. Tyanna explained that her tutors would say, "You know how to do this, really, you're just so good," encouragement she really "needed to hear." For Tyanna, receiving mathematical microaffirmations from tutors, whom she likely viewed as having mathematical authority, positively influenced her sense of belonging. Similarly, Marlina found encouragement when her class peers praised her work with comments like, "Oh you got it, good job," or "You did that well." These peer-based mathematical microaffirmations complemented those from professors.

Students' Perception of Professors as Caring, Supportive, and Helpful

To establish rapport and trust with students, which is necessary for sense of belonging, faculty must intentionally create classroom environments conducive to belonging. When students feel safe in a learning environment, they become more willing to share their experiences, risk asking questions without fear of judgment, and make mistakes as part of the learning process. For example, Julianna expressed that she feels she belongs, “when the teacher understands that I have problems in math and can try to help.” My findings align with extant research that shows when students perceive their professors as invested in their success and responsive to their needs, their sense of belonging in class increases (Freeman et al., 2007; Kirby & Thomas, 2022; Hoffman et al., 2002; Micari & Pazos, 2012; Barbieri & Miller-Cotto, 2021 Rainey et al., 2019).

Among the five students whose sense of belonging increased more than one standard deviation, four participants (Alexa, Jess, Marlina, and Tyanna) described their professor as caring or helpful. Britteny, whose belonging score began very high and increased further (though not by full standard deviation), also described her professor as someone she could count on.

Interestingly, of the four students whose sense of belonging decreased more than one standard deviation, three students (Faith, Imani, and Julianna) also perceived their professor as caring or supportive. This suggests that while positive professor perception contributes to a sense of belonging, it may not be sufficient on its own to counteract other negative factors. Participants identified five behaviors that led them to perceived professors as caring, supportive and helpful: (a) taking time to help students, (b) being responsive to students’ questions and concerns, (c) developing positive rapport with students, (d) demonstrated passion for teaching and mathematics, and (e) used supportive teaching practices. I discuss each of these behaviors in detail in the following sections.

Professors Took Their Time to Help Students

Alexa perceived her professor as caring and supportive because they consistently made time to help students outside of regular class hours. She explained, “[They] were always accessible during [their] office hours, so [they] made it really easy for us to go and ask if we did have any questions…[they're] always available for everybody." As course material became more challenging, Alexa began attending her professor's office hours more often and found these sessions beneficial. She appreciated that her professor "knew who to focus on for what classes, and the [professor] knew who to focus on the most, and it was very helpful despite having so many kids there." This personalized attention in group setting demonstrated the professor's commitment to address individual students' needs. The professor also offered additional support before exams, conducting evening Zoom meetings. These support opportunities reinforced Alexa's perception of her professor as genuinely interested in student success.

Alexa was very "grateful" for how her professor always did the "best they could" and went "above and beyond" for students. This relationship evolved into mutual respect, with Alexa and her peers helping the professor prepare the exam study guide solutions. She explained, "My professor helped us so much that she didn't make it feel like we were working on the stuff by ourselves [they] would go deep into, like, even if one student didn't get it, [they] would re-explain everything because I know I don't learn things on just like one instance."

This theme of professors dedicating time to student understanding appeared consistently across participants' experiences. Faith noted that her professor, "actually takes time out of her day and make sure we understand. I wasn't afraid to ask her a question." Britteny credit her professor with giving her "confidence in my math skills." Tyanna described her professor as "my favorite professor that I have. [They] take the time to teach you and help you even after class. I like when they give us a chance to show them that we want to learn and not just give up." Tyanna appreciated her professor patience in explaining even "easy" concepts when students asked questions, a practice that may function as a form of mathematical microaffirmation by signaling that all questions are welcome and valuable.

Professors were Responsive to Students' Questions and Concerns

Students particularly valued when professors promptly addressed their individual needs and concerns. Tyanna appreciated her professor's attentiveness: "When I had sent [them] an email, [they] took the time to read it and then get back to me and help me." Britteny similarly valued receiving "fast and in-depth" responses when emailing questions to her professor. Britteny highlighted how her professor actively encouraged classroom participation: "Everybody asked their own questions, and the professor would attend to each student's question."

Borth Britteny and Tyanna shared specific examples of how the professor's responsiveness enhanced their learning experience. When Tyanna struggled with using her scientific calculator, which she had never used before, her professor provided both immediate and ongoing support. She explained, "I think that's why I like [my professor] so much because … I have never used a calculator... I had to quickly learn how to use that. [My professor] always has extras and gave us resources to learn how to use them. That's just something I appreciated." Britteny valued how her professor encouraged questions from all students because "in classes like that, questions have to be asked. When you don't get an answer you were looking for, you lose lack of interest to do the work." Britteny perception of her professor as caring and supportive appeared to be influenced not only by how the professor responded to her questions, but also by how they replied to her peers' questions.

Several students described how professors demonstrated flexibility and accommodated their personal circumstances. Jess and Julianna both appreciated their professors' understanding when students needed additional time on assignments. Julianna explained that her professor "understood some of us had a lot of stuff on our hands, multiple jobs and stuff like that. [They] would give us extra time to finish the homework." Faith similarly felt supported when approaching her professor about grade concerns: "There was one point in the semester where my grade was worse than it is now. I went to talk to [my professor] about it to see if there was anything I could do. [They were] willing to work with me because I told [my professor] about what was going on. That was really helpful for me." Faith added, "This is probably the most positive learning environment I've ever been in when it comes to math."

Marlina described an incident in which she felt that her professor was caring and responsive. During one quiz, she felt frustrated that the problems did not reflect instruction and communicated this directly to her professor: "On one of the quizzes, I wrote that I'm frustrated because I don't understand how I'm supposed to solve for A, B, and C, if you never show me how to solve with these given variables." When the next quiz included problems more closely aligned with instruction, Marlina wrote "thank you so much" on her quiz paper. This responsiveness to her feedback was significant for Marlina and signaled that her professor cared about her input. Had her professor ignored her message, she might have felt ignored or insignificant in the classroom. She described her professor as a "great teacher" and "learned a lot of things" from them.

While Ana did not describe her current college algebra professor as supportive, she recalled a high school mathematics teacher whose patience and individualized approach impacted her success: "It was because of the teacher. She had a lot of patience with me and always helped me. She catered to my learning style, and I never felt judged with her. So, I ended up getting an 80 in her class and that was the highest I've ever done." Ana's reflection emphasizes the role of instructor responsiveness to individual learning needs can affect student belonging.

Professors Developed a Positive Rapport with Students

Positive professor-student rapport enhanced students' sense of belonging through professors sharing personal experiences and establishing themselves as someone students can depend on. When professors shared personal stories, particularly about their own educational journey and struggles, it helped humanize them to students. For instance, Alexa appreciated that her professor shared how they navigated challenges: "We would just appreciate all [their] stories that [they] would tell us about how learning and then teaching would be. It's interesting because then you get to really know them as a person, and see the other side of them, they're also human beings, not just our professors." Similarly, Britteny's professor shared personal background information: "[They] would explain where [they're] from and why they wanted to teach math." Britteny also valued how her psychology professor discussed life experiences and graduate school journey. Tyanna noted that her professor expressed "a lot about wanting to teach people" and helping students learn new things.

Moreover, students emphasized the importance of having professors they could trust and depend on. When asked what increased her sense of belonging, Alexa attributed it to "the teacher, getting to know [them], as someone I could trust." Similarly, Britteny described her professor as a dependable friend. Despite finding mathematics challenging, she felt comfortable in class due to her "really good professor and class environment." She elaborated,

> If you need help with something, [they are] always there like a shoulder to learn on. [They were] easy to talk to so that made the course easier to get through because when you're in a course for so long with a teacher, you have to get to know them, or it just has

> to be very easy to approach them. Like you bond over math. If I was going to miss class and I let the [professor] know, [they] would always tell me what I would miss and what I could do meanwhile I'm gone. That's what made me feel like I could depend on you, if I miss something, [they] could always fill me in with the missing details. That's how I would describe [my professor] as a friend.

These professor's intentional relationship building practices strengthened students' sense of belonging because students felt supported and valued in their classrooms.

Professors Demonstrated Passion about Teaching and Mathematics

Students valued professors who showed enthusiasm for teaching mathematics. Alexa described how her professor's energy changed the classroom dynamics: "At the beginning of the semester, it was a new class, not many people would talk but [the professor] would get us hyped because we have to work so everybody would participate. I have such a great teacher that was so passionate about teaching… [they] definitely have a passion for math and what she does. [The professor's] passion just reciprocated off of us. [They] always told me that math is so fun." Her professor's passion for mathematics energized Alexa's engagement in class.

Similarly, Tyanna appreciated professors who are passionate: "I like when teachers are passionate cause I know it's a really hard profession to continue for so long. I like when they give us a chance to show them that we want to learn and not just give up before." Faith also noted how her professor's love for mathematics enhanced her learning experience: "You could feel that [they] wanted to share [their] passion with us even if we didn't quite have the same level of understanding as [them], and that was helpful to me."

While discussing her professor, Tyanna recalled her experience with her high school chemistry teacher: "I just felt related to her in a way because I could tell she was passionate about chemistry, and even though in our environment everyone else wasn't as passionate, she would still love teaching it. Whenever I went into that classroom, I knew that I would learn something." Tyanna described how she felt calm yet engaged in her chemistry class: "It felt like a time for myself. We would listen to classical music and take notes. We had a chemistry notebook and we would make drawings and pictures and charts. It felt relaxing to have that." Her teacher's passion for chemistry and approach to teaching made her feel that she can do well in class: "Whenever we had tests, I felt like I always knew what to do. Then you would have to do labs, and I would incorporate it into my everyday life." This example from outside mathematics also reinforces how an instructor's enthusiasm for teaching and passion for the subject creates environments where students feel they belong and can succeed.

Professors Used Supportive Teaching Practices

The participants emphasized that understanding mathematics was a crucial component of their sense of belonging in mathematics class. It was important for students that their professor taught in ways that prioritized understanding using multiple strategies. Professors created supportive learning environments by welcoming questions, treating mistakes as natural parts of learning and re-explaining concepts, even if one student needed clarification. Through these practices, students felt valued, capable, and included in class, which enhanced their sense of belonging.

Professors fostered belonging by engaging with students during class, making sure that students did not feel left behind. Alexa described how her professor created a supportive environment: "My professor helped us so much that [they] didn't make it feel like we were working on the stuff by ourselves, even if one student didn't get it, they would re-explain everything. [They] would review and review … and make sure we would understand it. [They]'ll walk around the class making sure everyone's doing it correctly." Likewise, Leslie's appreciated how her professor made mathematics easier to understand: "[They were] fun with it as well … [they were] just really good in what they did, explaining the work and I understood it well from [them]. [They] always did it the easy way for us to understand it better instead of doing it the hard way. [They] would always help us find a way with acronyms and stuff to remember which was really good."

Several students valued professors who checked for understanding before moving forward. Britteny explained, "After we'd work out a problem, [they] would ask, does everybody understand? Is there something we need to go over? I've had classes where I wouldn't understand something and I didn't get any help, I would have to figure it out myself. While in this class, there was always support the whole time. So that made math class a pretty good class for me." Moreover, Britteny particularly appreciated that her professor created an environment where struggling was normalized: "If I didn't understand something, I didn't have to feel bad for not understanding because [they] would always be there to explain. Those interactions made me feel like I belong in the class, taking time out to answer each and everyone's question. That made me feel like I belonged in there."

Britteny also appreciated her professor's approach to that in-class assignments, which emphasized learning over performance: "If we didn't understand it, [they] would look at it and show us where were went wrong. It was more like for understanding. It was a grade, but it was more for our benefit of if we understand what we learned today. If we figured out our mistake and fixed it, [they] would grade it all over and give us points for back for that. All my ICAs, I've got 100 on them because [they do] help you to fix your mistakes." This focus on progress and improvement rather than penalizing mistakes, made Britteny feel that she could succeed with appropriate support.

Similarly, Tyanna appreciated her professor's instruction: "Some teachers explain things so advanced because I took pre-calc and so that teacher wouldn't go over the small things because she would assume that we already knew that. But [my professor] would go through everything no matter how easy it was, she would make sure we knew what we were on and what we did." She also noted that her professor used different colors when teaching and wrote out each step instead of "doing it in their head." Tyanna appreciated that her professor's teaching was "really straightforward" without assuming prior knowledge.

While not in mathematics class, Ana's experience in history class is another example of how supportive teaching practices can promote belonging. Ana appreciated her history professor's straightforward approach and various assessment methods: "All the quizzes were take-home so you could take time with it instead of feeling pressure and seeing all the students leave before you." For the final exam, students participated in an engaging scavenger hunt where they took pictures of historical monuments and planation artifacts throughout the city. Ana reflected, "So it really gave you hands-on experience and you were able to see and witness stuff." This suggests that various assessment approaches can enhance belonging by recognizing different learning styles and strengths.

A Professor's Demonstration of Care is Necessary but not Sufficient

Imani, Faith, and Julianna also described their professors as caring and helpful, despite quantitative results showing their sense of belonging decreased by more than one deviation over the semester. This suggests that although it is important for faculty to show care and give encouragement, that alone is not sufficient to significantly increase students' sense of belonging.

For instance, Imani explained that her professor was a “a big part” of her support system, “there to give you assistance if you needed it.” Faith described her professor as “nice, caring, lenient, thoughtful, fair, helpful” and said that they never made her feel discouraged. She added, “I know that my [professor] tried to make us feel like we all belong.” Her use of the word “tried” suggests she herself did not experience a strong sense of belonging in her mathematics class.

Similarly, Julianna described her professor as “good, positive, nice, and understanding” who helped her feel belonging by encouraging students that mistakes were expected and that the students were there to get better at mathematics. However, she said, “I feel like that’s the only reason why I felt I belonged” implying an absence of other belonging factors such as peer connection. When her professor encouraged the class to “think positive about math” she thought, “I’m trying. It’s just, I literally cannot do math.” While faculty care and encouragement are necessary components for belonging, that alone may not significantly increase students’ sense of belonging. This finding is consistent with previous research stating that students’ sense of belonging requires both academic and social support from professors (Zumbrunn et al., 2014, Freeman et al., 2007).

Professors Encouraged Peer Collaboration in Class

The third factor supporting students’ sense of belonging was that professors encouraged class collaboration. Five participants (Alexa, Britteny, Imani, Jess, and Leslie) reported experiencing varying degrees of peer interaction opportunities in their classes. Their belonging outcomes differed. Three students (Alexa, Jess, and Leslie) belonging scores increased by more than one standard deviation, Britteny’s belonging score increased slightly while staying high, and Imani’s belonging score decreased significantly. These findings align with research showing that collaborative learning enhances sense of belonging (Ong et al., 2011; Prasad, 2016; Zumbrunn et al., 2014)

Post-belonging scores also varied among the students. Alexa (4.97, +0.70 SD) and Leslie' (5.97, +1.99 SD) scores were above the mean, while Jess's (3.8, -0.82 SD) score was below, despite her increase. Britteny's belonging score remained high throughout the semester, starting at 5.87 (+2.13SD) and ending at 6 (+2.03 SD). Although Imani acknowledged her professor's efforts to encourage peer collaboration, Imani's score decreased from 5.27 (+1.25 SD) to 4.63 (+0.26 SD). This difference might be explained by examining the total number of positive factors experienced. While other participants reported experiencing three or more positive belonging factors, Imani experienced only two (caring professor and encouraged collaboration), suggesting that multiple positive factors may be necessary for maintaining or increasing sense of belonging.

Professors used various strategies to foster peer collaboration in mathematics classrooms. Imani's professor facilitated small group work at whiteboards, while Jess's professor arranged problem-solving in groups of two or three. Alexa's professor consistently "encouraged us if you have a question, to ask each other so [we] can help each other." By the end of the semester working together became a normal class routine: "everybody knew what to do already by the end of the semester and we would get up to go to our groups … and then we would just work on all the review problems." Leslie's class had a visible collaborative setup, with tables clustered in groups of five or six that students and professor arranged before each class. While discussing peer collaboration in mathematics class, Britteny also mentioned how her psychology professor's used group discussions which encouraged students to get to know one another: "Every class we had group stuff. I still have some friends from that class. I was always looking forward to it. We were able to share personal experiences. That was my favorite class in college for sure."

These collaborative structures fostered classroom communities where students felt comfortable relying on peers rather than solely on their professors. Imani valued the opportunity "to see it from a classmates' perspective on how they got it." Leslie found that, "working with them helped me learn it… it was being able to work with other people, and also it would be things that I didn't know before." Jess who worked with the same group throughout the semester, observed that, "after a while we learned how each other's minds work so it was easier to work with each other." Likewise, Brittney knew she could always depend on her peers: "When I did need help, there was always a peer that I could say, so I don't understand this, how did you do that, and they would always explain it."

In these classes, a sense of classroom community developed as the semester progressed. Alexa perceived that by the end of the semester each student in class belonged to a peer group: "Everybody had their own groups that they could talk to." Alexa noted that working in groups "made us realize who needs help with what. It was good because then we help each other out." She contrasted this with her Information Technology class, where students worked in isolation on computers without peer interaction.

Furthermore, small group interactions fostered a safe learning environment where students felt more comfortable asking questions and making mistakes without fear of peer judgement. Alexa explained how group work normalized struggles of learning mathematics: "If one person doesn't really get it, everybody else could help that one person or if the whole group is having a problem, it's probably just a harder question for all of us, then we would get [the professor] to help us." Imani emphasized the judgement-free class environment: "No one outed anyone for getting the wrong answer… you don't feel like you're being judged by your classmates."

Finally, peer collaboration made mathematics learning into an engaging and enjoyable experience for students. Leslie's appreciated structured group activities: "I really liked that. They were kind of fun to me." For Imani, working in groups was a positive change from her previous mathematics classes: "It was nice because you never really see group work in a math class. I've never seen group work in a math class before. So having us get up and do the problems of the topic we just went over was really nice." Jess found that group work enhanced both her understanding and enjoyment of mathematics. She appreciated how her professor balanced direct instruction with collaborative learning activities: "[They] would take [their] time teaching us and helping us understand. During math support, [they] would put is in groups. It would actually help a lot… it was pretty fun." These positive collaborative experiences strengthened students' sense of belonging by connecting students with both the mathematics and their class community.

Connection with Class Peers

When professors encouraged peer collaboration during class, students found it easier to develop connections and form friendships with their peers. This connection with class peers played a significant role in the students' sense of belonging in their mathematics class, as it served as another academic, emotional, and social support system. For instance, Ana mentioned that having a class friend made class more enjoyable. Similarly, Alexa said that "the peers were a big contribution to" her sense of belonging, while Britteny explained, "My classmates were important for how I felt" adding that they made her "feel valued and included in learning." Leslie also shared, "When you have friends in a math class, it comes off easier cause you're able to have someone to ask questions if you're struggling. If I'm alone in the class, I don't feel like I can ask questions to people around me ... I kind of like struggle in silence." These findings align with existing studies on belonging, which reported that peer relationships and support are crucial factor in students' sense of belonging (Booker, 2016; Hoffman et al., 2002; Hurtado & Carter, 1997; Locks et al., 2008; Prasad, 2014).

Alexa, Anela, Britteny, Leslie, Marlina, and Joselyn (six of the 13 participants) expressed that peer connections positively affected their sense of belonging in their mathematics class. Three of these students (Alexa, Britteny, and Leslie) reported that their professors also encouraged peer collaboration and were able to build *multiple* class peer connections. These students also had the highest post-belonging scores among the participants. The other three students (Anela, Joselyn, and Marlina) whose professor did not encourage peer collaboration sought out and formed single peer connections. Three (Alexa, Marlina, and Leslie) of the six students' belonging scores increased significantly. Marlina's belonging score increased by more than two standard deviations, while Alexa and Leslie's belonging score increased by more than one standard deviation. Britteny's score remained high from the beginning (5.87) to the end (6) of the semester. There was not a significant change in Anela and Joselyn's belonging scores. Anela's belonging score increased slightly by 0.17 standard deviations and Joselyn's belonging score decreased by 0.23 standard deviations. Moreover, Alexa, Leslie, and Britteny's post-belonging scores were higher than the post-belonging mean score, whereas Anela, Marlina and Joselyn's post-belonging scores were lower than the mean.

The participants relied on their peers for academic support if their professor was not available to help them or if they did not feel comfortable asking their professor for help. Alexa shared that while she felt comfortable approaching her professor for help, she would ask her peers first, especially if her professor could not help right away. Alexa would study with a group of class peers for hours at the library to prepare for exams. When Marlina got stuck on a homework problem, she would text her friend to ask for help. Similarly, Anela also studied at the library with one class peer she sat next to in class. Anela shared that the class peer made her feel like she mattered in the class: “She’s really the only person I talked to. She did a good job helping me, understanding things in the class, helping me feel welcomed.”

Academic support from class peers was also important for Britteny: “We helped each other, asked questions, and worked together to understand challenging criteria. I had a rough patch in math where some stuff I couldn't understand. But, in the end … some of my classmates helped me through the way and I ended up passing the class, which was pretty good.” Britteny said that one of her class peers started a class group chat, and they would use it to frequently ask each other about homework problems. The group chat was another avenue of getting academic support for Britteny: “If we didn’t want to email our professor, we had our peers.” Although peer collaboration was not part of the class routine, Joselyn made connections with class peers, and they tried to support one another. When stuck, she would text a class friend and ask her, “How’d you get to this problem or how’d you get to that?” and her classmate would try to explain it to her. Marlina sometimes felt a “disconnect” when the professor did not understand her or other students’ questions, but she said that her class peers together did a good job of clarifying what they meant to the professor.

Like Britteny, Leslie made a group chat for academic support, which strengthened her sense of belonging to her precalculus class: “One day I was struggling on the homework, and I didn’t want to email the teacher this late. And so, the next day I was like, we should make a group chat, and they were like, yeah, we can. I felt like I was part of something to be able to ask questions if I needed help or anything.” When asked what support systems helped her persist and overcome challenges in class, Leslie answered, “The group chat helped me a lot. If I was just complaining to my friend, this is so hard, they couldn’t really help me… they weren’t in the class to be able to understand. So, it was just the people in class that helped me the most. I did better in this math class knowing I have people that could always help me.” Leslie added, “I felt like I belonged because of my group.”

In addition to academic support, peer connections also provided emotional and social support which enhanced students’ sense of belonging. For Alexa, her class peers provided a “sense of security.” She knew she could rely on them for help, and they also depended on her.” Marlina felt encouraged when her class peer told her that she did well with her work. Marlina ended up asking that class peer to study together and invited her to her house: “Studying with her, I didn't feel alone in the class and I didn't feel like I was the only one who didn't get it.” Marlina and her class peer regularly met at her house to work on their classwork and “did everything together for the rest of the semester.”

Britteny also experienced strong emotional support from her class peers describing her class as feeling like a “big family.” Students not only discussed mathematics problems through the class group chat, but they also sharing encouraging messages before exams such as, “guys we got this, just try your best, it’s going to be okay.” These supportive peer interactions positively impacted Britteny’s sense of belonging despite her not liking mathematics: “The group chat encouraged me to get through the class, even though I don’t really like math, but I always felt like I belong. I hope that’s the same way for my peers, that I’ve made them feel like they belong, but they sure did make me feel that way.” For Britteny, these connections made the classroom more than just an academic space: “We all got to know each other. You know, it felt like I wasn't just like in a classroom. I was there to learn, but I could meet some very good people in that class. I didn't feel uncomfortable being in there. I felt pretty good. Having each other…made me feel like I belonged."

Positive connections with class peers also led to socializing outside of class, developing friendships with class peers, which positively contributed to the participants' sense of belonging. Participants discussed hanging out with their peers after class, eating together, studying together on campus, or going to their professor's office hours together. When discussing their class peers, Alexa, Britteny, and Marlina called them, "friends." Alexa expressed that spending time and talking with her class peers made her feel like an important member of the class.

Connection with class peers helped participants realize that they shared common struggles, which made them feel less isolated and enabled them to persist. Marlina explained that she suggested studying together because, "I realized we're both kind of not understanding certain things. Studying with her I didn't feel alone in the class, and I didn't feel like I was the only one who didn't get it." Similarly, Joselyn made a study group with a classmate when they realized that they were struggling. They met outside of school and reviewed quizzes together regularly. Joselyn felt like she mattered in the class when she realized that "there was a major point that we had in common, it was the fact that we were struggling to figure out how we were going to pass the class." The study group encouraged her: "Voicing my struggle to another colleague because if I didn't, I would've never made that study group…I would've never got to where I'm at now with my grade."

A commonality in the students' experiences with peer connection is that the students took an active role in creating a sense of community and shaping their sense of belonging in their mathematics class. This can be seen in the above examples with Britteny's peers forming a group chat, Leslie's initiative in creating a group chat in her class, and Marlina, and Jocelyn deciding to form study groups. The participants' initiative to create peer connections provided critical academic, emotional and social support which significantly enhanced their sense of belonging.

It is also important to note that none of the four students (Ana, Faith, Imani, Julianna) whose belonging decreased by more than one standard deviation reported feeling connected with their peers. However, three of them (Faith, Imani, Julianna) described their professor as caring, supportive, and/or helpful. This suggests that peer connections may be even more essential for mathematics class belonging than positive professor relationships. Another example that supports this interpretation is Anela and Joselyn's experiences. They both experienced mathematical microaggressions from their professors they characterized as uncaring, unsupportive, or unhelpful, and lacked peer collaboration in class, yet reported forming positive peer connections. Although both Anela and Joselyn's post belonging scores were below the mean, their belonging scores remained relatively the same did not decrease as much as expected. This suggests positive peer relationships may serve as a buffer and mitigate the harm from negative professor experiences. Conversely, students who reported both positive professor experiences and strong peer connections (Alexa, Britteny, Leslie, and Marlina) showed the most considerable belonging increases, indicating that when students have positive professor perceptions, peer connections can further amplify students' sense of belonging in mathematics class.

Positive Mathematics Self-Efficacy

As I discussed in Chapter 2, self-efficacy measures a student's belief in their ability to successfully complete a particular task (Warwick, 2008) and originates from Bandura's (1997) social cognitive theory. In mathematics education, mathematics self-efficacy is defined as a "a situational specific assessment of an individual's confidence in her or his ability fully perform or accomplish a particular task or problem" (Hackett & Betz, 1989p. 262). Mathematics self-efficacy encompasses students' interpretations of past achievements, self-assessment of their mathematical ability, and estimations of future performance. Researched has linked mathematics self-efficacy to sense of belonging, attitudes towards mathematics, major selection, student engagement, effort, mathematics anxiety, motivation, interest, learning approaches, and performance (Zakariya, 2022; Trujillo & Tanner, 2014). Zumbrunn et al. (2014) suggested that while students begin classes with existing conceptions of self-efficacy, higher self-efficacy is more likely to develop in classrooms that foster belonging.

Mathematics self-efficacy is developed through four sources: (1) mastery experiences, (2) social persuasions, (3) emotional and physiological states, and (4) vicarious experiences. *Mastery experiences* capture students' perceptions of their mathematical accomplishments, which provide the strongest source of mathematics self-efficacy. Students' past successful and positive experiences in working with challenging mathematical tasks strengthen mathematics self-efficacy. *Social persuasions* involve encouragement from teachers or peers, especially during difficult situations, which enhances mathematics self-efficacy. Students interpret their *emotional and physiological states* as an indicator of success or failure. Feeling secure, relaxed, and confident while engaging in mathematics activities can increase mathematics self-efficacy. Lastly, *vicarious experiences* involve students' self-evaluation of their mathematics competence when observing peers' success or failures in a mathematics task. Among the four sources of mathematics self-efficacy, vicarious experience may have the least influence on self-efficacy (Trujillo & Tanner, 2014; Usher & Pajares, 2009; Warwick, 2008; Zakariya, 2022).

The qualitative data indicates that mathematics self-efficacy fundamentally shapes students' sense of belonging in mathematics class, and vice versa. For instance, Alexa shared that she feels belonging when she “can do the work and understand it as much as anyone else.” Similarly, Leslie mentioned that “getting a good grade on my test” increased her sense of belonging.

Moreover, this relationship is bidirectional, with belonging also influencing students’ mathematics self-efficacy. Alexa stated, “If I feel like I don't belong, I just don't think would've been to participate so well in the class.” As Marlina’s sense of belonging increased, so did her mathematics self-efficacy: “At first, I dreaded it. My stomach would be in knots going in there. I just wanted to throw up before I went in there. I hated it. But at the end I looked forward to going. And I enjoyed it ultimately. I was proud of myself in the end… I didn't feel like I was bad at math anymore. I felt like if I applied myself, then I could accomplish things. That's where I felt that [belonging] increased.” These results align with research suggesting a positive association between sense of belonging and mathematics self-efficacy (Freeman et al., 2007; Hoffman et al., 2021; Trujillo & Tanner, 2014; Wilson et al., 2015; Zumbrunn et al., 2014).

Since positive mathematics self-efficacy is a factor I identified after analyzing the transcripts, it was not a direct question in my interview protocol. Moreover, I did not quantitatively measure students’ mathematics self-efficacy. Therefore, I analyzed mathematics autobiographies and interview transcripts for the four literature-based markers of positive mathematics self-efficacy: (1) mastery experiences, (2) social persuasions, (3) emotional and physiological states, and (4) vicarious experiences. For example, Leslie demonstrated positive math self-efficacy through *vicarious experience*: “class was actually very nice, and I didn't struggle too much. I feel like more students struggled more than me. I was one of the cases where it came easier.” Marlina developed mathematics self-efficacy through mastery experience: “At first it would take me 16 hours to do one homework because I felt like there was a block.

Then after the first test, the block was lifting, and I was able to do the work." Tyanna showed positive self-efficacy through emotional and physiological states: "I don't think there's ever been like I couldn't do something. I don't think there was anything hard … not all the answers were given to me, but everything I needed was given to me. So, nothing felt like I couldn't do it." I organized the quotes that I identified as current markers of positive mathematics self-efficacy according to the four sources using a table (Appendix J).

Using evidence from the four sources, I determined that Alexa, Leslie, Marlina, and Tyanna showed indication of positive mathematics self-efficacy. These four are among the five students whose sense of belonging increased by more than one standard deviation. I identified three sources of mathematics self-efficacy for Alexa, Leslie, and Tyanna and four sources for Marlina. I was unable to identify evidence of positive mathematics self-efficacy in the interview transcripts or mathematics autobiographies of other students whose sense of belonging stayed constant or decreased.

Several other participants showed signs of positive mathematics self-efficacy, including Anela, Britteny, Imani, and Jess as documented in the table. However, these students were not categorized in the positive mathematics self-efficacy due to insufficient evidence (only one or two supporting quotes), with more evidence indicating negative mathematics self-efficacy (which I discuss in detail under negative factors). For example, Britteny once loved mathematics during her elementary school years but no longer liked it after a negative 10th grade mathematics class experience and now considers it her weakness. This change demonstrates how students' mathematics self-efficacy can significantly change over time, based on their mathematics class experiences.

Leslie and Tyanna appear to have started the semester with high mathematics self-efficacy, both having positive experiences in high school mathematics and always having liked the subject. Leslie's belonging score started high (5.13, +1.04 SD) and increased further (5.97, +1.99 SD) by the end of the semester. She perceived her professor as caring and helpful and developed positive peer connections, though she did not receive mathematical microaffirmations. Since she already had high mathematics self-efficacy, the absence of mathematical affirmations may not have negatively impacted her sense of belonging, as she had one of the highest post-belonging scores among participants.

On the other hand, Tyanna's belonging score began low (3.53, -1.31 SD) but increased significantly to 4.2 (-0.30 SD), though it remained slightly below the mean. While she received mathematical microaffirmations and perceived her professor as caring and helpful, she lacked peer collaborative activities and connections. Had she developed peer relationships, she may have experienced an even greater increase in her sense of belonging.

Both Alexa and Marlina did not have positive mathematics self-efficacy at the beginning of the semester, but it increased alongside their sense of belonging. Marlina initially experienced anxiety and negative physical reactions in class: "I would shake like the entire class. Like my stomach would be enough just because I just felt like I didn't belong there. What was I doing? Everyone's going to know you're not good at math." These diminished after several classes, as she was able to do better: "I think my sense of belonging increasing definitely made me do better, because if I had continued to feel like, 'I hate this, like, I don't want to go to class, like everyone is like thinking that I'm dumb.' And if I continue to have that like, shadow on myself, I wouldn't have done well in the class. I think one of the questions on the survey was, 'You just want to hide and disappear into the back of that wall.' I didn't feel like that anymore."

Similarly, Alexa felt uncertain about her mathematics abilities at the beginning: “I think it was the beginning of the semester where it was just a specific set of problems that I was just like, I don't know what I'm doing. I don't know what's happening.” By the end of the semester, Alexa felt more confident in her ability to handle her mathematics course work, reflecting increased mathematics self-efficacy and contributing to greater belonging.

Alexa’s belonging score increased from 4.37 (-0.07 SD) to 4.97 (+0.70 SD), with a change greater than one standard deviation. Marlina’s belonging score rose from 2.83 (-2.33 SD) to 4.13 (-0.39 SD). Although Marlina’s post-belonging score remained below the mean, her increase was the greatest (+2 SD) among all participants. Both students received mathematical microaffirmations, perceived their professor as supportive, experienced peer collaboration, and developed peer connections. The interaction of these positive factors appears to have strengthened both their sense of belonging and mathematics self-efficacy.

Perception of Classroom diversity

The final factor positively influencing sense of belonging is the student’s perception of classroom diversity. Most participants (eight out of 13) indicated that diversity “didn’t really matter” in their mathematics class belonging. For instance, Anela said about her racial or ethnic background, “I don’t think it really influences my sense of belonging.” This aligns with the quantitative findings, which showed no significant differences in belonging based on students’ race, gender, or their intersection. Furthermore, the interview transcripts revealed no instances of racial or gender microaggressions in mathematics class.

These findings contrast with previous research suggesting minoritized female STEM students are more likely to feel a lack of belonging due to negative racialized and/or gendered experiences in STEM educational environments, particularly at PWIs (Barbieri & Miller, 2021;

Booker 2016; Ireland et al., 2018; Johnson et al., 2007; Johnson, 2012; Solorzano et al., 2000; Rainey et al., 2018). Given this institution's racially diverse context, most participants may not have felt the need to focus on their racial, gender or intersecting identities when discussing their belonging experiences during the interviews.

However, five students (Alexa, Ana, Britteny, Jess, and Tyanna) specifically discussed appreciating their college's diversity, and how their racial/ethnic identity influenced their belonging. Tyanna chose to attend this college because of its diversity she observed during a campus tour: "On the tour, it was Ramadhan, and they had a celebration for that, and it just made me want to come here more because that meant it was more open...I knew I would meet a lot more different people." Similarly, Britteny said, "[Diversity] is very important to me because, you know, [this] is a very diverse school. Like high school, it was mainly Black kids and entering college…the classes became more diverse…just seeing a whole bunch of different backgrounds, it's pretty cool that our cultures could clash together. We could all learn in a good environment."

Ana and Alexa, both identified as Mexican American, explained that it was easier to make friends with students who shared their cultural background and language. Ana mentioned that class diversity was "not too important, but sometimes if there is a girl in my ethnicity, we tend to stick together in classes." Alexa said, "Having that connection with someone, by being like 'Hey I'm from this place and you're also from this place' we have something in common." She described her study group as "all Hispanic. We're all different variations, we all kind of just understand where we're coming from." Ana agreed, "When you're in a class and you see somebody that knows the struggles that you go through and can speak the same language that you can speak, it's really exciting." She added that in classes where she had "Hispanic friends or just any friends at all, it was really easy to navigate the class cause you have someone to talk to and share your struggles with… it's just a little easier when they speak the same language and have the same troubles and know what you go through."

Britteny, Jess, and Tyanna, who identified as Black women, emphasized the importance of seeing other students who looked like them in class. Britteny stated, "I feel a sense of belonging when there's someone that looks like me in the class. Because I am African American, and it just makes me feel better to know that there's someone else in the class that looks like me… even though no one's ever made me feel some type of way for looking how I look. It's just been always important for me to have someone in there to just look like me." Similarly, Jess appreciated seeing, "a lot of people that looked like me" adding that it was positive to experience classroom diversity that differed from her hometown that felt segregated.

It was unclear whether Britteny and Jess referred to a Black woman specifically or a Black person in general when they mentioned "someone who looks like me." However, Tyanna explicitly stated, "Seeing other Black women makes me feel like I belong because it gives me a small sense of community…I know that you get me…I know you in a sense…even though I don't know you, we've probably most likely been through the same thing." Research indicates that minoritized female students receive messages that they do not belong in STEM educational environments based on their intersectional gender and racial identity (Booker, 2014, 2016; Alfred et al., 2019; Leyva et al., 2020). However, the participants in this study did not discuss their gender or racial identities as a prohibiting factor in their sense of belonging in their mathematics class.

Marlina, who identifies as Black and Latina, was the only student who emphasized the importance of finding a female friend in class. She explained that she chose to sit next to her current study buddy because she was female. Marlina stated, “Had she been a boy, I don't think I would have felt comfortable enough. Because there was a boy from my church in the class. And I never talked to him.” This may suggest that for some female students, having another female student in their groups during collaborative work is important for their sense of belonging.

For these five students, racial diversity was clearly essential to their sense of belonging in mathematics class. While seeing peers with similar backgrounds was important, they also valued interactions with diverse classmates. Strayhorn (2008) found that students who interact with peers whose background differ from one’s own report a greater sense of belonging. Furthermore, although Black women and Latinas share common experiences, both groups have distinct experiences differing from White women (Johnson, 2011; Pietri et al., 2019).

It is important to note that diversity alone is necessary but insufficient for creating inclusive learning environments and promoting belonging (Hurtado & Guillermo-Wann, 2013). However, when classroom diversity exists, students may not need to seek belonging experiences by creating “counterspaces” or “safe spaces” within classes, departments, or institutions. Diversity is essential not only for inclusivity but also for fostering belonging experiences for all students, particularly minoritized female students.

Model of Connections Between Positive Factors and Sense of Belonging

Using my analysis of interview transcripts and mathematics autobiographies, I developed a conceptual model that illustrates the six key factors that positively impact mathematics class belonging (Figure 5.1): (1) professor’s mathematical microaffirmations, (2) perception of professors as caring, helpful, and supportive, (3) professors encouraged peer collaboration, (4) peer connections, (5) positive mathematics self-efficacy, and (6) perception of classroom diversity. This model visually represents the interconnected relationships among the factors. In

Figure 5.1, the line arrows represent relationships between factors, and the thick arrows show relationships between factors and sense of belonging. Bidirectional connections are represented by arrows at both ends. While five factors appear as blue rectangles, positive mathematics self-efficacy is represented by a rhombus because students begin the class with existing mathematics self-efficacy, which serves as its own contributor to belonging.

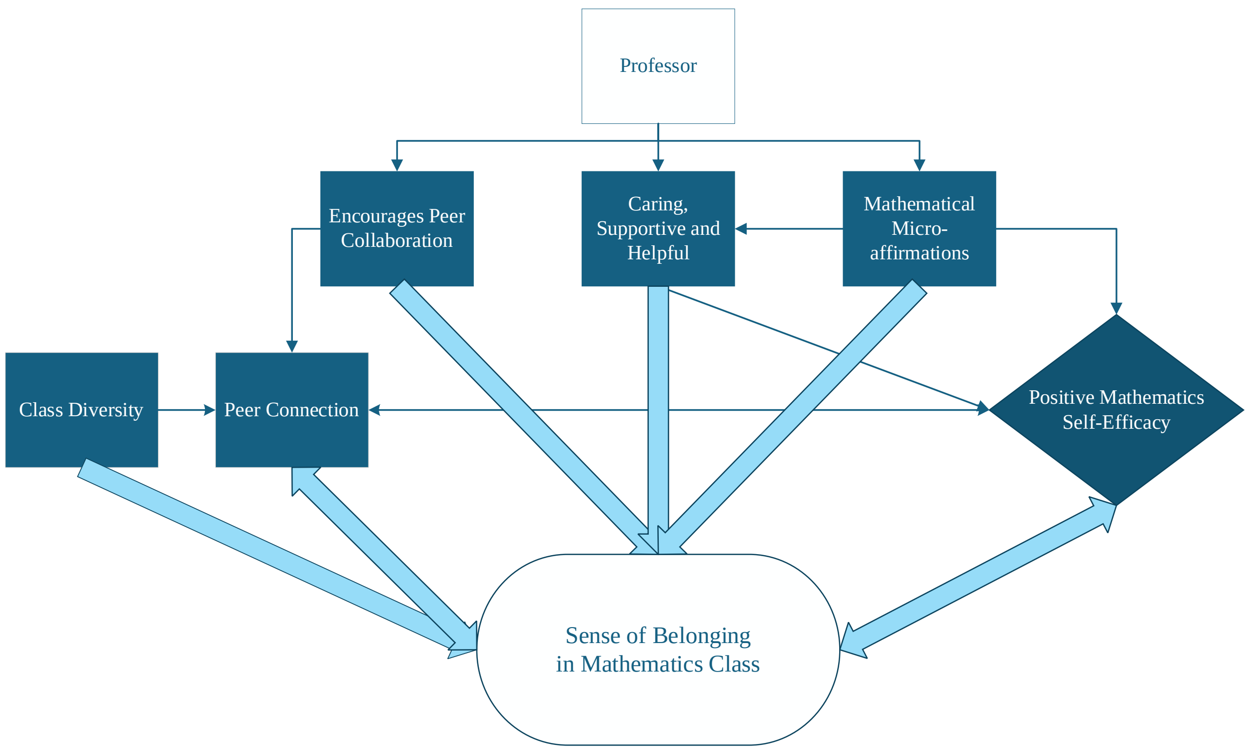

Figure 5.1 *Six Factors that Promote Sense of Belonging in Mathematics Classrooms*

The top of Figure 5.1 depicts professor-related factors that positively contribute to sense of belonging in mathematics classrooms for Black and Latina female students: encourages peer collaboration, students' perception of professor as caring, supportive, and helpful, and mathematical microaffirmations. These factors promote belonging through various pathways, with the diagram showing both direct (solid arrows) and indirect pathways (line arrows) to belonging. For example, mathematical microaffirmations impact belonging both directly and indirectly by fostering positive mathematics self-efficacy, which then enhances belonging. Similarly, students' perceptions of professors as caring, supportive, and helpful directly influence belonging while also contributing to belonging through positive mathematics self-efficacy.

Class diversity plays a significant role, directly contributing to students' sense of belonging while also supporting peer connections. The figure shows connected factors as well as gaps between connections. For example, there is no arrow between class diversity and positive mathematics self-efficacy, indicating that these factors function as separate rather than connected influences. However, there is an indirect pathway from class diversity, via peer connections, which in turn positively influence mathematics self-efficacy and ultimately belonging. All pathways converge on "Sense of Belonging in Mathematics Class" to show that multiple, complementary, interconnected factors work together to promote belonging.

Summary

Using participants' interview transcripts and mathematics autobiographies, I identified six key factors that positively impact students' sense of belonging in mathematics classrooms. First, professors' mathematical microaffirmations, which are small positive interactions that validated students' efforts and abilities, significantly enhanced belonging. Students receiving these microaffirmations were more likely to perceive their professors as caring, helpful, and supportive, which further increased their sense of belonging. Interestingly, some students felt supported by their professors even without these microaffirmations. When professors actively structured peer collaboration opportunities, students formed positive peer connections that provided emotional, academic, and social support, further strengthening their sense of belonging. Additionally, students with higher belonging were also more likely to engage with their peers, suggesting a reciprocal relationship. Positive mathematics self-efficacy emerged as a factor that both contributed to and resulted from belonging, creating a positive cycle. Finally, students' perception of classroom diversity, including gender, ethnicity, as well as different approaches to learning mathematics, enhanced their feelings of belonging. As illustrated in Figure 5.1, these factors function interdependently, often creating multiplier effects on belonging when they work together. Notably, students with higher belonging tended to experience more of these positive factors, although not all factors were necessary for positive belonging. In the next section, I will discuss factors that negatively influence sense of belonging in mathematics class.

Factors that Negatively Influence Sense of Belonging in Mathematics Class

The participants described several factors that negatively impacted their sense of belonging. Professors emerged having a key role in shaping students' classroom experiences and participants highlighted specific ways their professors have diminished their sense of belonging. When professors communicate either explicitly or implicitly that students are not valued or supported, students become reluctant to be vulnerable about their mathematical challenges. Consequently, students who perceive their professors as uncaring, unhelpful, or judgmental, stop viewing them as someone they can depend on and avoid interaction altogether. As a result, students not wanting to feel embarrassed or ashamed attempted to resolve their confusion on their own, often becoming frustrated and sometimes even giving up trying.

Additionally, participants also pointed to negative mathematics self-efficacy and past negative mathematics classroom experiences as factors that harmed their sense of belonging. In this section, I examine the six key factors that decreased students' sense of belonging: 1) professor's mathematical microaggressions, 2) students' perception of professors as uncaring, unsupportive, and unhelpful, 3) limited peer collaboration in class, 4) lack of peer connection, 5) negative mathematics self-efficacy and 6) past negative mathematics classroom experiences.

In Table 5.3, participants are arranged in the order of the difference between their pre-belonging and post-belonging scores, from lowest to highest. Similarly, in Table 5.4, students are organized in order of their post-belonging score from lowest to highest. The checkmarks (✓) in both tables indicate each student's experience with the six factors identified as harmful to students' sense of belonging in mathematics classrooms.

Table 5.3 *Participant's Belonging Scores and Negative Factors on Belonging, Listed in the Order of Change in Belonging Score, Least to Greatest*

Participants	Pre-belonging score 1-6 (Z-score)	Post-belonging score 1-6 (Z-score)	Post-Pre (SD)	Mathematical micro-aggression	Perception of professor as uncaring, unsupportive, and unhelpful	Limited peer collaboration in class	Lack of peer connection	Negative mathematics self-efficacy	Past negative mathematics classroom experiences
Ana	4.77 (0.51)	2.57 (-2.41)	**-2.2** (>3SD)	✓	✓	✓	✓	✓	✓
Faith	4.4 (-0.03)	3.5 (-1.20)	**-0.9** (>1SD)				✓	✓	
Julianna	3.83 (-0.87)	3.1 (-1.72)	**-0.73** (>1SD)	✓		✓	✓	✓	✓
Imani	5.27 (1.25)	4.63 (0.26)	**-0.63** (>1SD)						✓
Joselyn	3.93 (-0.72)	3.7 (-0.94)	**-0.23** (<1SD)	✓	✓	✓		✓	
Kayla	3.77 (-0.95)	3.6 (-1.07)	**-0.17** (<1SD)		✓	✓	✓	✓	✓
Britteny	5.87 (2.13)	6 (2.03)	**+0.13** (<1SD)					✓	✓
Anela	2.7 (-2.53)	2.87 (-2.02)	**+0.17** (<1SD)	✓	✓	✓		✓	
Alexa	4.37 (-0.07)	4.97 (0.70)	**+0.6** (>1SD)						✓
Tyanna	3.53 (-1.31)	4.2 (-0.30)	**+0.67** (>1SD)			✓	✓		✓
Leslie	5.13 (1.04)	5.97 (1.99)	**+0.83** (>1SD)						
Jess	2.87 (-2.28)	3.8 (-0.82)	**+0.93** (>1SD)					✓	✓
Marlina	2.83 (-2.33)	4.13 (-0.39)	**+1.3** (>2SD)	✓		✓			

Table 5.4 *Participant's Belonging Scores and Negative Factors on Belonging, Listed in the Order of Post-Belonging Score, Lowest to Highest*

Participants	Pre-belonging score 1-6 (Z-score)	Post-belonging score 1-6 (Z-score)	Post-Pre (SD)	Mathematical micro-aggression	Perception of professor as uncaring, unsupportive, and unhelpful	Limited peer collaboration in class	Lack of peer connection	Negative mathematics self-efficacy	Past negative mathematics classroom experiences
Ana	4.77 (0.51)	2.57 (-2.41)	-2.2 (>3SD)	✓	✓	✓	✓	✓	✓
Anela	2.7 (-2.53)	2.87 (-2.02)	+0.17 (<1SD)	✓	✓	✓		✓	
Julianna	3.83 (-0.87)	3.1 (-1.72)	-0.73 (>1SD)	✓		✓	✓	✓	✓
Faith	4.4 (-0.03)	3.5 (-1.20)	-0.9 (>1SD)				✓	✓	
Kayla	3.77 (-0.95)	3.6 (-1.07)	-0.17 (<1SD)		✓	✓	✓	✓	✓
Joselyn	3.93 (-0.72)	3.7 (-0.94)	-0.23 (<1SD)	✓	✓	✓		✓	
Jess	2.87 (-2.28)	3.8 (-0.82)	+0.93 (>1SD)					✓	✓
Marlina	2.83 (-2.33)	4.13 (-0.39)	+1.3 (>2SD)	✓		✓			
Tyanna	3.53 (-1.31)	4.2 (-0.30)	+0.67 (>1SD)			✓	✓		✓
Imani	5.27 (1.25)	4.63 (0.26)	-0.63 (>1SD)						✓
Alexa	4.37 (-0.07)	4.97 (0.70)	+0.6 (>1SD)						✓
Leslie	5.13 (1.04)	5.97 (1.99)	+0.83 (>1SD)						
Britteny	5.87 (2.13)	6 (2.03)	+0.13 (<1SD)					✓	✓

Professor's Mathematical Microaggressions

Mathematical microaggressions are subtle communications from authority figures, such as faculty, that signal to students that they do not belong in mathematics through their language, behavior, and assumptions. When experienced repeatedly, these microaggressions negatively affect students, especially those already experiencing self-doubt (Su, 2015). These mathematical microaggressions appear as unintentional *microslights* (faculty saying, "It is obvious," or asking, "Are there any questions?") or intentional *microinsults* aimed at harming students' mathematical identity and perception of ability (Cawley, 2023). Faculty may often be unaware of how mathematical microaggressions damage students' sense of belonging, as demonstrated by the students in this study.

Among the 13 participants, five students (Ana, Julianna, Jocelyn, Anela, and Marlina) reported experiencing mathematical microaggressions. Ana, Julianna, and Jocelyn's belonging score decreased, with Ana and Julianna's decrease being more than one standard deviation. Anela's belonging score started very low and remained low, while Marlina's belonging score increased by more than one standard deviation. Notably, Marlina was the only participant who experienced both mathematical microaggressions and microaffirmations, which I discuss later in this section.

Most mathematical microaggressions reported were professors' mathematical microslights directed at the entire class, such as, "It's easy," "This is high school stuff," "You should drop out of the class if you don't get this" or "You should already know this." These comments made students feel discouraged or unintelligent, especially when they did not remember certain topics from high school or struggled to grasp new concepts immediately. For instance, Ana's professor would say, "You should already know this, so we're just going to skip this step." When her professor repeated statements such as "Oh, you don't get this, maybe you should drop out of the class right now" or "If you don't get this you're definitely not going to understand that," she said it made her feel "I wasn't smart enough… personal insecurities made me feel like I didn't belong." This contrasts with Alexa's professor's microaffirmations encouraging students that there are different ways of understanding things: "If you don't get it this way, you can learn it this way."

Other participants shared similar experiences. Jess recalled her professor's frustration or impatience when students did not understand concepts based on high school content. Joselyn felt discouraged from asking “questions or to even say anything about the class” after witnessing her professor’s responses to a classmate’s question, “as if he should have known.” Likewise, Marlina felt excluded when her professor said, “This is high school stuff. You don't know this?” without reviewing the problem she asked about, which she found unhelpful: “That doesn’t help. I obviously don’t know it.”

Ana shared detailed accounts of mathematical microaggressions. She expressed that she wished her professor would not make students feel bad about not understanding precalculus concepts. Comments such as “This is review,” “Everybody should know this already,” or “You don’t get this this, maybe you should drop out of class,” made Anela feel insecure and believe that her professor thought everybody in the class was bad at mathematics. When she encountered a mathematical microaggression, Anela described feeling,

> Let down because maybe I should know this but even though everybody in this class is struggling with review topics, it’s not something that you should keep calling out we should know this. How about let’s practice this or let’s go over this quick since I see that majority of you are having a problem with it. That’s what I would say. I just didn’t like her tone... I feel like, don’t yell at me, don’t raise your voice at me. I’m just here trying to learn. I just want to get this and you’re yelling whether you mean it or not. [They’re] always snapping on how people in math should know certain stuff and [they] would go on and on about nowadays how people aren’t getting stuff. Once you keep hearing that, it’s annoying and it makes you feel okay, why [are they] going on and on about this? Are you trying to say it’s going on in our class? I felt like [they were] calling me stupid, when [they] would yell at me. I don’t want to hear how everybody should know this already. We’re in school for this reason. Everybody’s not perfect.

Anela's professor may not have been aware that Anela perceived her tone as "yelling" and that her comments unintentionally diminished Anela's sense of belonging in the class. Su (2015) emphasized that teachers must consider how their actions and words can affect vulnerable students, though mathematical microaggressions can be difficult to self-diagnose. Even unintentional mathematical microaggressions harm students' belonging, making it crucial for faculty to actively work on avoiding them altogether.

Some mathematical microaggressions can appear as microaffirmations on the surface. For instance, Julianna explained that her professor did not make her feel ashamed for not doing well in her mathematics class. The professor told students to "think positive about math" and that their lack of understanding may be due to their having a "negative aspect of math." The professor said, "it was okay to make mistakes because we could always try again" and that failing a class was "okay" because they have "an extra try. You can always pass again."

Initially, I coded this statement as a mathematics microaffirmation because it appears to be encouraging and affirming. However, upon further reflection, I coded this incident as a mathematical microaggression. While I do not doubt the professor's good intentions, this statement implies that the professor expects some students to fail and trivializes failing a gateway mathematics course, which can have serious adverse effects on GPA, financial aid status, program progression, and academic standing. Moreover, it attributes the failure to students' negative attitudes towards mathematics rather than examining their pedagogical approaches, suggesting that the failure can be fixed by simply thinking positively about math. This perspective removes accountability from the professor and places the blame on the student.

Julianna was unaware whether her professor had regular office hours and was instructed to email them if she had questions. She shared, "My grade was a 60 in the middle of the semester and that was during the time we could withdraw. But I had a talk with my teacher after class. [They were] saying that maybe I could do better in the class, I could try my best to get up to a 70. That kind of encouraged me and I was like I won't withdraw, I'll try my best but I didn't do well." For Julianna, her professor encouraged her to do her best, but she lacked practical support and guidance from the professor.

Mathematical microaggressions harms students' sense of belonging by undermining their mathematics self-efficacy and willingness to be vulnerable and ask questions. These mathematical microaggressions made participants feel "stupid," or not as smart as their class peers. After experiencing a mathematical microaggression, Marlina observed, "That made people ask questions less about maybe the obvious things. Because you didn't want to seem dumb. I would never ask questions about like quadratic formula, factoring, anything of that nature, because I felt like it was supposed to be a given that I knew that. I didn't ask questions about it, even though I didn't understand it." When students refrain from asking questions in class, they assume everyone else understands except them, which lowers their sense of belonging in class. For instance, Tyanna felt that "everyone gets the work and I'm out of place" when no one asked questions.

As mentioned earlier in this section, Marlina was the only participant who experienced both mathematical microaffirmations and microaggressions from her professor. Simple encouragements such as "Good job, [Marlina]," helped her believe, "I'm getting it. I can do this." However, when her professor would say things like "factoring, this is high school stuff, I'm not going over that," she felt discouraged about concepts she did not remember making it harder for her later in the semester.

Interestingly, Marlina's belonging score increased significantly from the lowest pre-belonging score to slightly below the mean post-score, the highest increase (+1.3) among all participants. This suggests that mathematical microaffirmations may have dampened the negative effects of mathematical microaggressions, alongside other positive factors, such as peer connections, perception of a supportive professor, and increasing mathematics self-efficacy. Had Marlina only experienced mathematical microaffirmations and not mathematical microaggressions, her belonging score increase could have been greater, and her post score may have been higher than the mean. Research confirms that mathematical microaffirmations increase students' sense of belonging while mathematical microaggressions decrease it (Cawley & Wilson, 2023); Cawley et al., 2023; Su, 2015), though their interaction effects remain understudied.

Students' Perception of Professor as Uncaring, Unsupportive, and Unhelpful

Research underscores the importance of positive student-faculty interactions and student perceptions of their professor as encouraging, caring and supportive for students' sense of belonging, particularly for minoritized or female students (Booker, 2016; Barbieri & Miller Cotto, 2021; Hurtado et al., 2015; Johnson, 2012; Kirby & Thomas, 2021; Strayhorn, 2013; Zumbrunn, 2014). Conversely, when faculty are perceived as critical, sarcastic, condescending, or verbally aggressive, students' sense of belonging in class can diminish (Wilson et al., 2015).

In my study, I found that students' negative perceptions of professors as discouraging, unsympathetic, unapproachable, or unhelpful, contribute to a lower sense of belonging in mathematics classrooms. For example, Alexa does not feel belonging in a mathematics class, "when the teacher doesn't really care for their students and how well they do or don't get the subject." Four students (Ana, Anela, Joselyn, and Kayla) described their professor as uncaring, unsupportive, or unhelpful. Among these students, Ana's sense of belonging decreased by more than three standard deviations, while Anela, Joselyn, and Kayla's belonging scores remained low throughout the semester. All four students' pre- and post-belonging scores were below the mean: Ana and Anela's scores were more than two standard deviations below, while Joselyn and Kayla's scores were approximately one standard deviation below the mean.

An important pattern is that none of the participants whose belonging scores increased by more than one standard deviation, mentioned perceiving their professors as uncaring, unsupportive, or unhelpful. This finding strengthens the connection between student perceptions of their professors and their belonging. Participants perceived their professor as uncaring, unsupportive, or unhelpful when their professors: (a) did not develop a positive rapport with students, (b) explained concepts in ways that students could not understand, or (c) were rude, critical, or condescending. I discuss each of these characteristics in detail below.

Professors Did Not Develop a Positive Rapport with Students

Throughout the interviews, four participants (Ana, Anela, Joselyn, and Kayla) reported failing to develop positive connections with their mathematics professors. For instance, Kayla mentioned that her professor "wasn't interactive with the students" resulting in minimal encouragement and communication. Similarly, Joselyn described having no interactions and consequently never experiencing any encouragement.

In Ana's case, she perceived favoritism, with her professor repeatedly interacting with the same four outgoing students during class while never learning her name throughout the entire semester. When reflecting on her experience, Ana expressed that the most challenging aspect was "feeling a bit of an outsider for not being as outgoing" and "not really getting along with the teacher." She wished her professor had made efforts to engage with all students, which would have made him seem more approachable. Ana felt “too scared and embarrassed to get help and it felt like the teacher wasn’t there to help me.” Likewise, Anela emphasized how her sense of belonging was directly influenced by her relationship with the professor: “I definitely could have done better in class if me and the professor had some type of connection. I’ve had more of a connection with other professors. I felt like I would’ve been more comfortable to ask questions that I needed.”

The impact of professor rapport becomes more evident through Ana’s contrasting experiences in other courses. While she was unsuccessful in mathematics class this semester, Ana “did really good in all my other classes.” She described her English professor as “very nice, very helpful,” particularly appreciating how this professor provided individualized attention to each student, taking time to sit with every person to discuss assignment plans. The professor also implemented structured feedback processes requiring rough draft submissions with detailed responses and offering weekly extra credit opportunities to further enhance student engagement. The difference between Ana’s positive English class experience and her mathematics class experience emphasizes how a professor’s approachability and personalized interaction directly influence students’ overall sense of belonging.

Professors Explained Concepts in Ways That Students Could Not Understand

Four participants (Ana, Anela, Joselyn, and Kayla) reported that their professors’ explanations were incomplete and lacked necessary detail, making the content difficult to understand. When struggling to understand the material, they frequently assumed they were the only ones “not getting it” which intensified their feelings of not belonging in the class. Both Kayla and Anela noted that their professors’ explanations were not thorough and omitted explanations. Kayla explained, “There was certain steps that wouldn’t be shown on the screen.

You have to figure out how to get to the next step … and [they] would just walk through it explaining the problem. I need help when it comes to math to be taught thoroughly through the steps and everything and go over practice problems rather than just doing it.” Similarly, Anela observed, “[They] moved too fast for me. They just write, write, write, write, write. In math I need to see where are you at in that? Where did you get that number from? That was the hardest thing about the class, trying to figure out little details in their teaching… If I asked her to explain something, she would not thoroughly explain it. Like I need you to break it down by step.”

Additionally, when students asked questions, they felt their professor either misunderstood what they were asking, or provided explanations that did not make sense to them. Anela described this communication gap: “It’s that [they are] not explaining what I need to know, [they’re] not understanding my questions. So, I’m getting a whole different explanation, and I already know that I need to know this.” Joselyn shared a similar frustration: “When I did ask, it was more of [they]’ll just redo the problem again, but it wasn’t educational. It wasn’t very well explained thoroughly when I had asked. So, there’s times where I don’t feel comfortable asking today because we’re just redoing the problem without explaining as to why we got to each step and not just to the end without explaining from the middle.”

Professors Were Rude, Critical, or Condescending

Students’ sense of belonging dramatically decreased when they perceived their professors as critical, condescending, or unempathetic. Ana expressed not feeling like she matters in mathematics classroom when teachers are “belittling students or not listening to student feedback.” She described a troubling incident where her professor made an insensitive comment to a student who needed to leave early to pick up their child: “Next time tell your kid that class doesn’t end until 4:15pm.” Though Ana assumed the professor intended it as a joke she felt “it just came off as super rude and the student also didn't think of it as a joke." Similarly, Anela recalled when her professor publicly held up a student's calculator and pointed out that it was inappropriate for the class. Anela recognized this could be embarrassing for students unable to afford the required graphing calculator, even if the professor did not intend any harm. Ana and Anela's experiences highlight how students' observations of professors' negative interactions with other students also adversely affect their sense of belonging in the mathematics class.

Anela described her professor's behavior as "very discouraging," noting: "I felt like [my professor] complaining and always yelling and criticizing a student always got in the way of me learning. All I'm trying to do is learn here… I didn't feel comfortable at all. I felt like [they] would try to embarrass me in front of the class. I don't want to be called out." For Anela, it was difficult to make sense of her professor's behavior. Eventually, Anela rationalized her negative experience because: "I justified everything with [my professor] being a little older and I realized that I wasn't the only person saying what I was saying when I looked at rate my professor, so it made me realize it is what it is. I'm pretty sure [they] mean well. Did something happen in [their] day? I try to think that so I'm not one sided."

Ana described another negative encounter when she asked her professor for permission to reschedule her exam due to a court date. Her professor allowed the makeup but did not inform her it would take place in his office. When Ana went to the classroom and found it empty, she emailed her professor who responded with an "passive-aggressive" tone, making Ana feel "mad, sad, and very stupid." During this part of the interview, Ana became visibly upset and read her professor's email verbatim with a trembling voice. The interaction left Ana feeling discouraged, embarrassed, and ultimately led her to skip the test and accept a zero rather than face her professor again.

As a first-generation first-year student, Ana was learning how to navigate college. She perceived the email interaction with her professor as hostile and discouraging and even feeling ashamed that she was unaware of going to her professor's office for make-up exams. Mathematics faculty should be more understanding, especially with first-year students in college algebra and precalculus, who may be unfamiliar with college norms. When asked what her professor could have done differently to increase her sense of belonging, Ana replied, "Maybe [their] attitude at times, the passive-aggressive comments. That was a big thing for me that made it really difficult to be there."

Despite this negative experience with her college algebra professor, Ana contrasted it with a time when she had succeeded in mathematics during high school, attributing this success to her teacher's supportive approach: "The only time I ever succeeded in math on my own where I had a decent grade, was geometry, and it was because of the teacher. She had a lot of patience with me. She always helped me and she catered to my learning style." Significantly, Ana added that she "never felt judged with her."

When students perceived professors as uncaring, unsupportive, or unhelpful, they became reluctant to be vulnerable as mathematics students and feared embarrassment. They did not want to go to class or considered withdrawing from the class. Ana wished she had withdrawn while Anela and Kayla considered it but continued despite feeling discouraged. After missing several classes, Anela returned because she felt, "I had no other choice. That's my professor for the moment, and I got to learn this material somehow. What made me stay was just telling myself I can do it." Kayla ended up failing college algebra but planned to retake the course with a different professor.

When students felt that they could not rely on their professor for support, they stopped asking questions and relied on others for help or unsuccessfully tried to figure it out on their own. After determining that she could not go to her professor for help, Joselyn got help from her previous high school mathematics teachers, as she was working there: “Mr. [D.] helps me…just trying to get us to pass the final. I try to get any of my teachers, so I was able to get at least some type of tutoring.”

Anela became quiet in her mathematics class after witnessing how her professor responded to other students’ questions. One time, her professor asked why she did not ask questions: “I didn’t want to tell [them], but I’m like, do you see how you react when these other people ask questions? I’m like I’m okay, I will sit here. I will ask you after everybody is gone, to ensure I don’t look stupid.” When Anela didn’t understand something, she preferred asking a student next to her or figuring it out herself. She explained that having a connection with a professor makes her feel more comfortable asking questions. Kayla also avoided asking her professor questions: “At first, I would ask the teacher a bunch of times and [they] would explain it, but I still felt like I didn’t understand it and I just didn’t want to keep continue to asking [them]. So, I just try to figure through my notes but even that didn’t really help.”

Limited Peer Collaboration in Class

Another factor identified as detrimental to students’ sense of belonging is the lack of opportunities to collaborate with peers in class. My findings align with literature that emphasizes the importance of group work, peer support, and a sense of class community, particularly for female or minoritized students (Locks et al., 2018; Ong et al., 2011; Winkle-Wagner, R., & McCoy, D. L. 2018). Seven students (Ana, Anela, Joselyn, Julianna, Kayla, Marlina, and Tyanna) discussed not having sufficient class activities that encouraged collaboration or developed their sense of belonging. Among these students, Ana and Julianna's belonging scores decreased by more than one standard deviation, while Anela, Kayla and Joselyn's belonging scores remained low. Although Marlina and Tyanna's belonging scores increased by more than one standard, all seven students' post-belonging scores remained below the mean.

Participants described classes that were mostly lecture-based with minimal peer interaction. When group work was assigned, students expressed confusion about expectations and described the work as more independent than collaborative. Additionally, they observed that when professors asked for participation, only a small group of students volunteered or were selected to participate. The participants described three features of their non-collaborative mathematics classes: (a) the class was primarily lecture-based, (b) there was a lack of clear guidelines for groupwork and (c) a select few students dominated participation. I discuss each of these features below.

Class was Primarily Lecture-Based

Students described mathematics classes that involved more passive learning approaches. Kayla's professor projected slides on the screen and read them aloud without writing anything on the board, which made it difficult for Kayla to understand. Joselyn described her class as "just quiet, trying to learn, trying to get through this type of class." Similarly, Ana described her class as a "big lecture" where students took notes on a packet while the professor lectured. She felt that the class activities were not effective for her: "I'm not sure what is the best way for me to learn… I don't believe that's the best way that I would have learned… the class was mostly individual note taking."

Although Julianna and Marlina did not describe their professor as uncaring or unhelpful, both described their classes as heavily lecture-based. Marlina noted her professor covered "examples after examples… and everyone's just speed writing things." Julianna mentioned students did not work together, and her way of participating was simply "showing up to class."

Julianna contrasted her mathematics class experience with her English class which had greater peer interaction: "So everyone knew each other… they would interact more. They would help each other more." She valued the real-world relevance in her English class: "I feel like we had discussions, we would talk about stuff that were going on outside of our classroom like real world-type stuff." Reflecting on this difference between the two classes, she added, "I felt more free in my other classes, like not really follow the rules. I think that's a lot funner than math. I feel like in math, you have to follow formulas. In math, I felt a little more anxious, I felt like I had a time limit."

Participants found the lack of student interaction in lecture-based classes unhelpful. Joselyn's professor assigned problems for students to solve individually without collaborative opportunities. Kayla described a similar experience: "[The professor] would just walk around to see if you were doing the work that you were told to do and did the same thing every day, go over the notes, go over the slideshows, walk around the classroom, and go back to the desk and repeat basically. I didn't feel like I got much help from the notes that we were taking because I didn't understand even after we were told to do it on our own." This isolation weakened students' sense of belonging as Joselyn explained, "We all belonged simply because we needed the class to graduate, because we didn't really communicate, we didn't talk. It was a very quiet, non-interactive class."

Students expressed a desire for structured, interactive class activities. For instance, Tyanna shared that group work causes anxiety when finding group partners, but she would not mind if her professor assigned groups to avoid the stress of choosing herself. Kayla wished that her professor used more engaging teaching approaches rather than just saying, “This is how you do it, and this is how you do that.” She found online resources “more helpful than actually being in the class. It was just really the slideshows every day.” While lectures and individual work may not necessarily harm belonging, relying solely on these approaches does not foster class belonging. Students wanted more than listening to a lecture and taking notes; they wanted meaningful interactions with professors and peers beyond simply attending class and working independently.

Lack of Clear Guidelines for Groupwork

Occasionally, the professor asked students to work together in small groups. However, participants reported uncertainty about how to collaborate effectively due to a lack of clear guidelines or class norms regarding groupwork. Students needed more direction than simply being told to get into groups and work together. For instance, Anela’s professor would instruct students “You guys need to talk in your groups. Talk. Talk.” Similarly, Kayla’s professor would say, “You guys go ahead and give it a try and talk to your neighbors about it… see if you guys got the same answer.”

Participants described how students often worked individually within groups, only comparing answers after completion without discussing problem-solving process or strategies. Julianna explained that during pair work, “I wouldn’t talk to the person next to me. They would be doing the work and I’d be doing my work.” Despite frequently getting stuck, she did not ask her group member for help. After they both finished, her classmate would attempt to explain the solution, but Julianna still struggled to understand.

Anela experienced similar group work dynamics: “The people I were in groups with were quiet. If we’re all quiet, how can we get anything done? So, it was basically independent work.

Instead of us coming together and trying to figure out these problems together as a group, we were doing it separately. I wouldn't say that's working together." In Kayla's class students were asked to compare answers, but there was no group discussion. Instead, the professor "would go over it and put the steps on the slideshow and "would be like, this is the answer, and you do this." Kayla explained, "I wouldn't say it was a group activity necessarily. I would say it was more of a discussion as to what we did to get to where we are."

In Marlina's class, the only group opportunity involved taking group quizzes together at the end of class. Although she appreciated these interactions, she never learned her groupmates' names or got to know them very well because "we're normally trying to work so fast and we didn't have time to be like, what's your name?" While this limited peer interaction was better than none for Marlina' sense of belonging, having class opportunities to develop stronger peer connections would have been more beneficial.

Many students expressed lacking confidence when working with peers because they did not understand concepts well enough. Kayla explained, "We would all be confused because we didn't know necessarily how to do it… It was hard to learn just through slideshows and not anything else and then having to somewhat depend on my neighbors in a way." Conversely, Julianna felt nervous working with other students because she believed that they understood "more math" and "what they were learning" while she was the only one struggling. Having a learning disability also made her self-conscious about her slower pace. Julianna explained that when she "didn't understand stuff in the class," she felt she did not belong explaining that this "would just ruin my whole mood… it made me think so negatively against math." When asked why she thought her sense of belonging score decreased over the semester, she answered, "having to not understand the math and I wasn't really liking it… and just feeling discouraged."

Despite these challenges, Kayla expressed a desire to learn by working with others: “I don’t work well with just looking at notes every day. I think group activity is one of my best ways on how to learn because I can learn through other people as well, through other strategies because not all the time professors have strategies that students can learn from.” She suggested activities such as “Jeopardy” would create a “more inclusive” environment that would “not make students feel like we just have to do notes every day and it’s just a boring and overwhelming environment. ‘Cause especially nowadays students need a lot more involvement in activities especially with other people like social interactions.”

While frequent peer collaboration can significantly enhance class belonging, faculty must intentionally develop and foster classroom norms and clear expectations to support productive group work throughout the semester. As the participants discussed, simply grouping students without structure did not promote belonging. For these participants, “group work” meant solving problems independently in silence, then comparing answers afterward, while instructors showed the solution to the class. Mathematics faculty can share classroom authority by allowing students to provide meaningful input in decisions about classroom practices and positioning them to use one another as mathematical resources (Bartell et al., 2017).

A Select Few Students Dominated Class Participation

In addition to unclear guidelines for group work, participants reported that classroom norms were not established to ensure equitable involvement, with the same group of students consistently volunteering. Bartell et al. (2017) identified research-based K-12 mathematics teaching practices that promote equitable engagement opportunities, which can be applied to the post-secondary education setting. These practices include drawing on students’ funds of knowledge, establishing classroom norms for participation, positioning students as capable, monitoring how students position each other, and explicitly attending to race and culture. These practices can help students, particularly those from nondominant backgrounds, develop strong mathematical identities, which may promote sense of belonging in mathematics class.

In Anela, Ana, and Marlina's classes, when professors asked students to come up to the board, the same group of students would usually volunteer. Anela observed that certain male she described as "kind of like class clowns" would go to the board: "Some classes, [the professor] would offer extra credit for solving problems. The same students kept coming up for points. [The professor] would have to beg somebody who's never gotten points, come to the board and nobody would." Anela assumed students avoided going to the board because, "maybe some people don't want to be embarrassed because they didn't understand something." Ana noted a similar pattern in her class: We'd do the problems in our seats, and then [the professor] would ask people if they want to go up and work it out…and it was usually the same four students." She identified these students as, "same students, they're the outgoing students… the students that [the professor] got along with the most." Marlina's professor specifically selected students who solved problems correctly to present their work and "it was the same students that went up."

Ana, Anela, and Marlina recognized an inequitable pattern in which students were positioned as capable in mathematics. These students were typically male, outgoing, or had a good rapport with the professor. It is not surprising that Ana and Anela, whose belonging scores decreased during the semester, never volunteered to share their work due to fear of being wrong and being embarrassed in front of the whole class. In contrast, Marlina, whose belonging score increased, volunteered to present sometimes, but only when she was certain her solution was correct.

While both Ana and Anela's professors tried to encourage student participation by offering extra credit points, this approach potentially fostered an individualistic competition for some students. Boaler and Greeno (2000) argued that such competitive environments in mathematics classrooms may prevent students from developing a sense of belonging. Although likely unintentional, allowing the same fast and correct students to dominate participation appears to have reinforced the idea that mathematics professors value only quick, correct solutions. This approach eliminated opportunities for students to process their thinking, to compare multiple strategies, or learn from others' misconceptions and errors. In classrooms where participation classroom norms privileged correct answers, quick-thinking, and outgoing personalities, participants felt discouraged from contributing, negatively impacting their sense of belonging.

Lack of Peer Connection

In classes with limited peer collaboration and a weak sense of class community, students found it more challenging to develop peer connections on their own. Research has shown that minoritized female students often leave STEM majors in college due to social isolation, limited peer relationships, and a lack of sense of belonging (Ong et al., 2016). Furthermore, studies indicate that students with stronger class peer connections tend to have higher academic self-efficacy, increased engagement, and greater motivation compared to those with lower sense of belonging in class (Wilson et al., 2015; Zumbrunn et al., 2014). Additionally, when students perceive their professors as caring and supportive, they not only feel more connected to their instructors but also to their peers (Kirby & Thomas, 2021).

Ana, Faith, Julianna, Kayla, and Tyanna discussed not being able to interact or develop connections with their class peers, often resorting to completing coursework independently. In the classes of four participants (Ana, Julianna, Kayla, and Tyanna), there were either no opportunities for peer collaboration or the existing opportunities did not foster deep peer relationships. Ana, Faith, and Julianna's post-belonging scores were below the mean, with their decreases exceeding one standard deviation. Kayla's post-belonging score was also below the mean, although her decrease was less than one standard deviation. Tyanna's post belonging-score was slightly below the mean (-0.30 SD), but the increase was greater than one standard deviation.

Tyanna was the only participant among these five students who experienced the most positive factors for class belonging: mathematical microaffirmations, perceptions of professor as caring, class peer collaboration, positive mathematics self-efficacy, and perception of classroom diversity. For Tyanna, these positive factors appear to have boosted her sense of belonging. However, the lack of class collaborations and peer connections may have prevented her sense of belonging from increasing further.

Faith also reported experiencing some of the positive factors such as mathematical microaffirmations, professor as caring, and class peer collaboration. Nevertheless, her weak mathematics self-efficacy appears to have diminished the collective positive effects on her sense of belonging. When discussing her classmates, Faith said, "They were nice. I can't really say too much more. When we were in class, if I had a question, they would help me." However, because she felt that she was doing poorly in class, she restricted her collaboration with peers: "I chose not to only because I was doing bad in the class I didn't want them to have a question and then not be able to rely on me because I didn't understand. I didn't want them to help me but me not being able to help them. So, I didn't rely on anyone in the class. My grade is not good, so I don't want to teach them wrong or bring their grade down if they've been working hard."

The absence of class peer connections is particularly problematic because it isolates students both in and outside of class, consequently making them feel alone, significantly dampening their sense of belonging. For instance, when Julianna struggled with homework, she attempted to solve problems independently without success: "I would try to go on YouTube and watch them go over the problem… and that would confuse me more." Kayla felt that she did not belong because she did not have "anyone to really talk to" in class which made her feel alone, overwhelmed and made her think, "Why am I in this class?" Likewise, Ana experienced isolation because despite her efforts to make friends, there was no one in class that she got along with on a "personal level." Although a student in Ana's class made a GroupMe chat to facilitate class communication, nobody actively participated (unlike the extensive use of GroupMe in Britteny's class). Unfortunately, Ana felt that she was the only one in class without a peer group: "Everybody had a partner or a little friend group."

Conversely, Ana had a very different experience in her English and religion classes where she developed a positive peer connection: "I took English class and I had a friend in there" She was female and she was Muslim. We got along really good. We were friends and we shared two classes so it made it really easy to get through the classes." In religion class, having that friend "made it really easy because if we didn't understand something we just tell each other and always had each other to remind about all the tests, we'd review before. And it was just easy. Having her in the class was a big help in passing." Ana's contrasting experiences clearly demonstrate that meaningful class peer relationships are fundamental to fostering a sense of belonging in any class, contributing to both academic success and emotional well-being.

One thing I observed when visiting the classes to administer post-surveys at the end of the semester was the noticeable drop in the number of students present across sections. High

DFW (drop, fail, withdraw) rates in gateway mathematics courses remain a major issue for both the mathematics department and the institution. Withdrawing from class negatively impacts the student who withdraws, but it also appears to undermine the sense of belonging of students who choose to remain in class. For example, after Kayla's friends withdrew from class, she felt alone and unmotivated, illustrating how attrition can lower class belonging by further isolating the students who remain:

> I had two friends at the beginning of class, and so many people just dropped it including my two friends that I made. So it was difficult 'cause I felt kind of alone. At first me feeling motivated thinking that I could possibly pass this class… but because my two friends left … the motivation didn't stick with me. With the two friends we could talk about how we felt with the class and ways we can help each other within the math class… because they were there, I wasn't as overwhelmed as I was compared to when they did leave. The person next to me was like, "so many people dropped this class" so I feel like a lot of people felt the same that they couldn't pass because it was hard and it was overwhelming and the environment just…I didn't have that social interaction and I'm a very social person and I just felt more and more alone… and like I don't think I can do this.

Despite lacking structured in class opportunities for peer collaboration, some students were still able to develop connections with their peers. For instance, Anela occasionally studied with one classmate, which provided her with some academic support outside of class. She said, "I had a study partner named [Ava]. She's really the only person I really talked to. She did a good job helping me understand things in the class and helping me feel welcomed." Anela started interacting with Ava because Ava talked to her first in class.

Joselyn and Marlina, who were in their early twenties and slightly older than most of their first-year class peers, took a more proactive approach. Recognizing the importance of peer support for their success, they initiated connections by asking others if they wanted to study together. As a result, Joselyn formed a study group with one friend she could regularly depend on, and Marlina frequently had study sessions at her house with another peer. These examples show that even in the absence of structured in-class collaboration, students can still build meaningful academic relationships by taking initiative and seeking out opportunities to connect with others.

A significant distinction between ‘Jocelyn and Marlina’ and ‘Britteny, Leslie and Alexa,’ is that the latter group had greater ease in forming peer connections. Their professor’s frequent incorporation of collaborative class activities provided structured opportunities for interaction, enabling them to build relationships with multiple peers. However, not all students proactively initiated connections as Joselyn and Marlina did. This highlights the need for faculty to intentionally design activities that foster peer engagement. While in-class collaboration does not guarantee peer connections, it lowers the barrier for peer relationship building by encouraging shared goals among students and normalizing group interaction. Therefore, faculty must prioritize collaborative learning because not only does it directly foster students’ class belonging, but also indirectly through the peer relationships that emerge from repeated class interactions.

Negative Mathematics Self-Efficacy

The qualitative data demonstrates that negative mathematics self-efficacy significantly undermines students’ sense of belonging in mathematics classrooms. Students with negative mathematics self-efficacy consistently reported feeling isolated in their mathematics class. For example, Jess felt that among her class peers, she was “the only one who’s mathematically behind" while Julianna explained that not understanding concepts made her "dread to go to class" and "feel so upset" afterward. Kayla explained how not knowing the material and always struggling in mathematics made her feel like she did not belong in class. Furthermore, Ana expressed, "the more I knew that I couldn't get it, I couldn't do it, it's discouraging, where one gives up." For some of the participants, mathematics class felt like an insurmountable obstacle.

These findings align with previous research suggesting within STEM contexts, diminished levels of academic confidence reinforce feelings of not belonging, particularly among women and students of color (Seymour & Hewitt, 1997; Johnson, 2012). Moreover, the relationship between mathematics self-efficacy and sense of belonging appears to be complex and multidimensional. Negative self-efficacy contributes to a reduced sense of belonging which in turn further reinforces negative self-efficacy, creating a crippling self-fulfilling prophecy-cycle.

I identified mathematics self-efficacy as a factor affecting student belonging during my qualitative data analysis, though I did not include it in my quantitative measurements. To identify participants with negative mathematics self-efficacy, I analyzed interview transcripts and mathematics autobiographies for evidence of the four established sources of mathematics self-efficacy: (1) mastery experiences, (2) social persuasions, (3) emotional and physiological states, and (4) vicarious experiences (Trujillo & Tanner, 2014; Usher & Pajares, 2009; Warwick, 2008; Zakariya, 2022). For example, I classified Julianna as having negative mathematics self-efficacy through mastery experiences because she stated, "I've always struggled with math since I was young." Participants showing evidence of negative indicators in at least three of the four sources were classified as having negative mathematics self-efficacy. I organized participants' quotes according to these four sources in a table (Appendix J).

I identified eight of the 13 participants (Ana, Anela, Britteny, Faith, Jess, Joselyn, Julianna, and Kayla) as having consistently negative mathematics self-efficacy throughout the semester. When examining changes in belonging scores, Ana, Faith, and Julianna's belonging scores decreased by more than one standard deviation, with their post-sense of belonging falling below the mean. Joselyn's belonging score showed a slight decrease, though her score remained below the mean throughout the semester. Anela and Kayla's belonging scores remained low at one standard deviation below the mean with no significant changes. Britteny's belonging score remained higher at two standard deviations above the mean despite negative mathematics self-efficacy. Jess's belonging score increased by more than one standard deviation, though her post belonging score remained below the mean (Table 5.3).

Although there was evidence of negative mathematics self-efficacy from Alexa, Imani, Marlina, and Tyanna, I did not include them in the negative mathematics self-efficacy group for several reasons. For Imani, I could identify only one quote suggesting negative mathematics self-efficacy, making her the only participant not placed in either the positive or negative mathematics self-efficacy category. Additionally, Alexa, Marlina and Tyanna showed evidence of developing a more positive mathematics self-efficacy by the end of the semester. While Tyanna's transcript had indications of positive mathematics self-efficacy, she specifically struggled with test anxiety rather than broader mathematical concerns. In Alexa and Marlina's case, their mathematics self-efficacy appears to have increased concurrently with their sense of belonging by the end of the semester.

Negative mathematics self-efficacy appears to decrease the sense of belonging primarily because students feared being "judged" and "embarrassed," which consequently led them to disengage from both their peers and coursework. For instance, Joselyn hesitated to ask questions because she feared that peers would make fun of her. Likewise, Ana was “too afraid” and found it “embarrassing” to admit needing help. Jess actively tried to hide her struggles from peers and felt frustrated about not knowing how to approach problems.

Faith’s negative self-efficacy directly affected her classroom participation: “I’m more quiet when I don’t understand. I tried to figure it out on my own. I don’t want to be a bother.” Likewise, Jess described disengaging during group work: “If I don’t understand it, I’ll just let someone else kind of take over.” Their fear of being labeled as “bad at math” created a destructive cycle; students avoided working with peers, which led to reduced engagement and isolation, reinforcing negative beliefs about their mathematical abilities.

While past negative mathematics experiences and professors’ microaggressions lower the sense of belonging, they also appear to do so indirectly by negatively impacting mathematics self-efficacy. Participants shared how their past negative mathematics experiences contributed to diminishing their mathematics self-efficacy. For instance, Julianna mentioned, “In elementary school and middle school, I was always struggling in math.” Jess explained that changing elementary schools five times caused her to miss learning key foundational concepts. Ana reported that she had “always struggled with math and had bad experiences,” explaining that her “math teacher just assumed that I didn’t know how to do it and instead of taking the time to teach me [they] kind of just left it alone.”

Furthermore, students described how teachers and professors’ mathematical microaggressions undermined their mathematics self-efficacy. Anela stated that her professor was “actually discouraging” and they would tell students, “If you don’t get this, you’re definitely not going to understand that” which made her feel that she “wasn’t smart enough,” and contributed to her not wanting to attend class. Ana felt embarrassed when her professor said things such as “you should already know this,” making her feel like her professor “wasn’t really there to help me.” Jess recalled that her high school teacher assumed she was joking when she disclosed not understanding basic concepts due to frequent school changes. Instead of helping her, Jess said they gave up on her: “In high school, I would tell like one of my teachers, certain stuff I didn't learn like other people because I was barely in school my elementary, and she was like, ‘well, you got to get it together’. She didn't try to help me.”

Although qualitative data suggests that negative mathematics self-efficacy leads to a decreased sense of belonging, the impact can be mitigated by having positive professor and peer connections. Despite having negative mathematics self-efficacy, Britteny maintained her sense of belonging while Jess increased her sense of belonging. Britteny never felt like she did not belong, describing her class as a “big family” and professor as a “friend” who “helped me through the way.” Similarly, Jess’s belonging score increased substantially over the semester as supported by the statement: “I started to feel a little bit more comfortable and not like I’m bit of an outcast. “

The cases of Marlina and Alexa demonstrate that mathematics self-efficacy can improve significantly when students’ sense of belonging increases through supportive professor interactions and positive peer relationships. While I categorized students into positive or negative mathematics self-efficacy groups for the purpose of analysis, the qualitative results suggest that mathematics self-efficacy functions as a dynamic, changeable construct rather than a fixed trait. This fluidity is similar to what can be observed in students’ sense of belonging. As Strayhorn (2019) explained, sense of belonging requires continuous nurturing and evolves as circumstances and contexts change. Through consistent positive mathematics classroom experiences over time, students develop a more stable sense of belonging which strengthens their mathematics self-efficacy, creating a cycle that further enhances their overall sense of belonging in mathematics class.

Past Negative Mathematics Class Experiences

Students' past negative mathematics class experiences emerged as a factor weakening their sense of belonging in current mathematics classrooms. I identified three similarities across students' negative experiences in both past and current mathematics classrooms: teachers' mathematical microaggressions, insufficient teacher support, and limited peer connections. Eight of the 13 participants (Alexa, Ana, Britteny, Imani, Jess, Julianna, Kayla, and Tyanna) reported negative experiences in their K-12 mathematics education. These past experiences were associated with varying outcomes in their current sense of belonging. Ana, Julianna, and Imani's belonging score decreased by more than one standard deviation. Kayla's belonging score remained consistently low, while Britteny's score remained high despite past negative experiences. Alexa, Jess, and Tyanna's post-belonging score improved by more than one standard deviation. Notably five of these eight students (Ana, Britteny Jess, Julianna, and Kayla) were also classified as having negative mathematics self-efficacy.

Participants described teachers who lacked empathy and understanding of students' difficulties. These teachers often conveyed unrealistic expectations for students to understand immediately, creating environments in which students felt judged and belittled through mathematical microaggressions. Julianna recalled being publicly embarrassed in class for not completing tests on time. Alexa said, "I truly didn't understand what we're doing in class and the way my teacher talked to me made me feel like I was dumb." Similarly, Tyanna reported that her eighth-grade mathematics teacher "couldn't understand why somebody else couldn't get it" and would make dismissive comments such as “Well, this is easy,” or “How can't you get this?” These interactions discouraged Tyanna from asking questions because she feared her teacher would think that she is “stupid by asking these things.”

Beyond mathematical microaggressions, participants described classes with insufficient individualized support, leaving them feeling isolated and helpless in their mathematical learning. Ana, Jess, and Tyanna discussed how this lack of support affected their learning experiences. When Tyanna asked her math teacher for help, they would respond, “Well we went over this,” making Tyanna feel that she “just had to push through it” without guidance. Similarly, Ana went for tutoring twice a week to improve her grades but her teacher “would just put a computer in front of my face and say to make up all my missing work.” Even during these tutoring sessions, Ana found that her teacher “wasn't always available to help” and “instead of taking the time to teach me, she kind of just left it alone.”

In addition, four participants (Alexa, Imani, Julianna, and Tyanna) described classroom environments that failed to foster meaningful peer connections. Imani remembered not feeling as “smart as other people” when her peers laughed at her for getting the wrong answer, but her teacher did not intervene. Due to that experience, she never raised her hand in mathematics class. Alexa described a statistics class where “none of the classmates talked to each other” and they all “would just do our work” creating an isolating environment. Similarly, Julianna felt “left out” during collaborative activities, while Tyanna responded to her negative class environment by choosing to “close in” and “keep to myself.” These experiences again highlight how classroom structures can damage students’ sense of belonging.

For many participants, these negative experiences began in elementary grades, resulting in long-term feelings of failure and anxiety around mathematics. These prolonged mathematical struggles without adequate support contributed to their negative mathematics self-efficacy. Importantly, these participants lacked sufficient opportunities to develop their positive mathematics self-efficacy. Four participants (Ana, Jess, Julianna, and Kayla) identified unresolved gaps in their foundational mathematical knowledge from elementary grades that continued to impact their achievement in subsequent mathematics courses. Ana explained, “It began in elementary school and then it just continued on until I was older. I felt I was too far behind to catch up in my math. I still have difficulty with simple math problems, division, multiplication, and my level is so far behind at a third grade’s level that it’s difficult to catch up now to algebra. I’m not sure how I’ve been passing every single math class because I don’t know enough math.” Similarly, Julianna said, “In elementary and middle school, I was always struggling in math… so I already know that I’m not going to do that well.” When students experience persistent struggle without meaningful help, they perceive themselves as less mathematically capable than their peers, and mathematics classrooms become spaces where they feel they do not belong.

Britteny’s experience shows how a single negative teacher experience can transform a student’s relationship with mathematics: “I used to love math as a kid. I had a really bad teacher in 10th grade. If you didn’t get it, she doesn’t care. I felt signaled out. It was either you get with it, or you fail… the focus wasn’t on the learning experience. It felt like our teacher was bullying us for not grasping the material. My teacher made us feel insignificant.” This experience resulted in a complete change in her attitude toward mathematics: “After that I really didn’t like math. She just ruined my whole math experience.” Britteny now views mathematics as merely a “class I must pass to graduate” and expressed regret in this change stating that “math used to be a subject I excelled in, but I completely lost my passion for it.”

Importantly, students began their new college mathematics course with hope, anticipation, and excitement despite past negative experiences. As Kayla said, “I had a lot of motivation at first, I felt good starting off my first year of college and with math.” Furthermore, participants distinguished between finding mathematics challenging and feeling a lack of belonging, suggesting that difficulty with mathematics does not determine belonging. Kayla explained, “I don’t think I felt like I did not belong in the class just because it is math class.” Similarly, Anela said, “I actually like math. I enjoy math, especially if it's with the right professor. I'm not the best at it though.” Participants’ sense of belonging was primarily shaped by the relational aspects of classroom experiences and how they were treated by their teachers and peers, rather than by the subject itself.

Finally, Alexa, Britteny, Jess, and Tyanna’s stories provide evidence that past negative experiences do not determine students’ sense of belonging in current or future mathematics contexts. Despite their histories of negative mathematics classroom experiences, these four students demonstrated positive belonging outcomes, with three showing significant increases in belonging scores and one maintaining a high score. Their current mathematics class experiences featured more positive factors and fewer negative factors on belonging. This finding emphasizes that mathematics professors hold both the power and responsibility to disrupt negative cycles and cultivate learning environments in which all students can develop a sense of belonging, regardless of prior mathematics class experiences.

Model of Connections Between Negative Factors and Sense of Belonging

Using my qualitative data findings, I constructed a model (Figure 5.2) illustrating the relationship between sense of belonging in mathematics class and six negative factors: 1) professor’s mathematical microaggressions, 2) perception of professors as uncaring, unsupportive, and unhelpful, 3) lack of peer collaboration in class, 4) lack of peer connection, 5) negative mathematics self-efficacy, and 6) past negative mathematics classroom experiences. The model depicts how these interrelated factors contribute to students' diminished sense of belonging. Five negative factors appear as blue rectangles, while negative mathematics self-efficacy is represented by a rhombus to indicate that students enter the class with pre-existing mathematics self-efficacy. Single headed arrows show directional influences between factors, while double headed arrows indicate bidirectional relationships. The model also displays how strong peer connections and/or perception of a supportive professor serve as protective factors (represented by a dashed oval), potentially buffering students' belonging against negative factors (shown through dashed arrows).

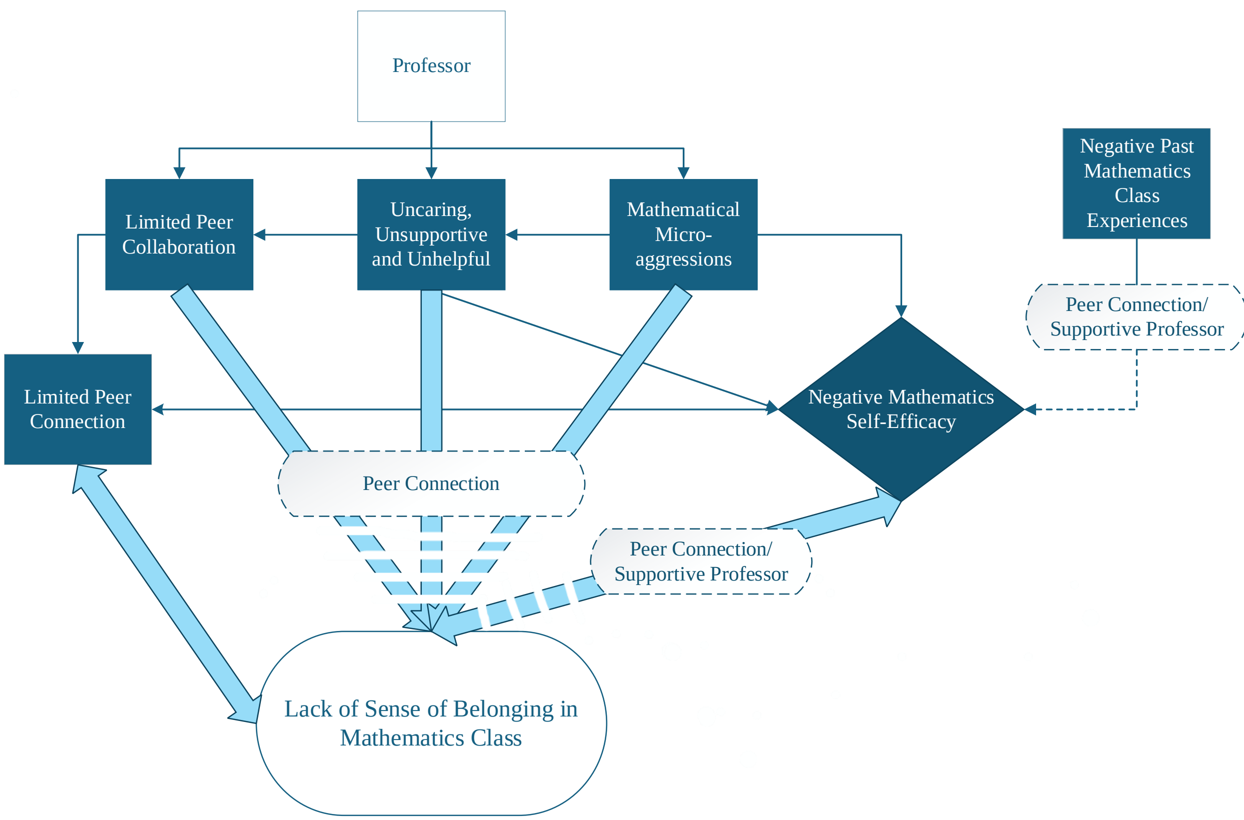

Figure 5.2 *Six Factors that Diminish Sense of Belonging in Mathematics Classrooms*

At the top of Figure 5.2, I depicted professor-related factors that directly contribute to a lack of sense of belonging in mathematics classrooms for Black and Latina female students: limited peer collaboration, students' perception of their professors as uncaring, unsupportive, and unhelpful, and mathematical microaggressions. These elements connect to belonging through different pathways, with solid arrows indicating direct influences on belonging, and line arrows showing the indirect influences on belonging through other factors. The diagram highlights a bidirectional relationship between negative mathematics self-efficacy and lack of belonging because these factors reinforce each other. That is, when students doubt their mathematics abilities, their sense of belonging decreases, and feeling out of place further diminishes their mathematics self-efficacy.

Other relations are unidirectional, such as how negative past mathematics experiences influence mathematics self-efficacy but not belonging directly. The rounded rectangles with dashed lines represent possible mediating factors. For example, peer connections and supportive professors can buffer certain negative factors and may weaken their influence on belonging. Some elements do not have connections between them (such as limited peer connections and mathematical microaggressions) to represent separate rather than interconnected processes. The multiple pathways converging on "Lack of Sense of Belonging in Mathematics Class" demonstrate how it emerges because of interrelated classroom factors, rather than from a single factor.

Summary

In the second half of this chapter, I identified six factors that diminish students' sense of belonging in mathematics classrooms. These factors formed an interconnected network of reinforcing effects. For example, mathematical microaggressions and uncaring professors undermine mathematics self-efficacy, which further lowers sense of belonging. Similarly, unsupportive professors using only lecture-based teaching approaches and negative mathematics self-efficacy limited peer connections, which also discouraged belonging. Finally, prolonged past negative mathematics class experiences resulted in negative mathematics self-efficacy which impacted their current class belonging. In mathematics classrooms where these factors are present, students feel isolated, hesitant to participate, and question whether they belong.

The findings reveal that students' sense of belonging is shaped primarily by the relational aspects within the classroom rather than by mathematics being perceived as difficult or intimidating. Importantly, the findings show that students with past negative experiences developed positive belonging when professors created supportive environments, indicating that past experiences do not necessarily determine current or future belonging. Some students with negative mathematics self-efficacy reported an increase in their belonging when they experienced positive protective factors, such as supportive professors and positive peer relationships. This evidence underscores the need for mathematics professors to foster classroom environments in which all students can develop a sense of belonging, regardless of their prior mathematics experiences or pre-existing mathematics self-efficacy.

CHAPTER 6

INTEGRATION, DISCUSSION & CONCLUSIONS

In this chapter, I discuss how the findings of my study contribute to a deeper understanding of Black and Latina female students' sense of belonging experiences in introductory mathematics courses at a diverse minority serving institution. The central research question guiding this study is: *How do their identities as Black and Latina female students play a role in their sense of belonging in gateway mathematics classrooms at a racially and ethnically diverse open access institution*? This inquiry is especially important as a strong sense of belonging has been recognized as a key factor in the persistence and academic success of minoritized students in STEM fields (Kirby & Thomas, 2021; Strayhorn, 2019; Museus et al., 2017; Wilson et al., 2015).

My study contributes to the growing body of literature on belonging by using a sequential explanatory mixed methods approach with a complementarity purpose. This design allowed for a more comprehensive understanding of students' experiences, with qualitative data providing richer insights that quantitative measures alone could not fully capture. I begin the chapter with an integrated analysis of the findings from both the quantitative and qualitative phases. I conclude the chapter with a discussion of the study's implications, limitations, and directions for future research aimed at fostering students' sense of belonging in mathematics classrooms.

Overview of Integration of Mixed Methods (Quantitative and Qualitative) Findings

To gain a more comprehensive understanding of how Black and Latina female students experience belonging in mathematics classrooms, I integrated the quantitative and qualitative findings during the interpretation phase. The integration involved aligning the quantitative results with corresponding qualitative themes to create a cohesive narrative. Following the guidance of Creswell & Creswell (2023), I used a joint display table to connect the data sources, as recommended for explanatory sequential designs. Table 6.1 presents a visual representation of this integration, fulfilling the complementarity purpose of the mixed methods approach. The table is organized into three components: (1) quantitative findings from the first phase, (2) corresponding qualitative themes, and (3) metainferences. These metainferences are interpretive conclusions that explain how the qualitative themes enrich and extend the quantitative results (Creswell & Creswell, 2023). Following the table, I provide a detailed discussion of each connection, supported by evidence and participants' quotes, to illustrate how the qualitative findings enhance the interpretation of the quantitative data.

Table 6.1 *Integration of Quantitative and Qualitative Findings on Black and Latina Female Students' Sense of Belonging in Mathematics Classrooms*

Quantitative Finding	**Qualitative Theme(s)**	**Metainferences**
Finding 1: Black and Latina female students' pre-, post-belonging, and belonging change mean scores were comparable to other racial and gender groups. The only statistically significant difference in pre-belonging was Latina female students mean was slightly lower than those of Black male students (p = .026, Mean Difference =-0.24)	Theme: • Perception of Diversity	• The comparable belonging scores across racial and gender groups (with only a small significant difference between Latina and Black male students at the beginning) appear to be influenced by the students' perception of racial and gender diversity within the mathematics classrooms at this diverse minority-serving institution. • Black and Latina female students valued seeing peers with shared identities and being able to form connections with students from similar backgrounds.

		• Participants did not report any instances of racial or gender microaggressions during the interviews. • Individual differences in belonging scores were influenced by factors such as mathematics self-efficacy, professor interactions, peer connections, and past mathematics experiences rather than race and gender identity.
Finding 2: Mathematics affinity (*p*<0.001) and expected course grades (*p<0.05*) had a significant influence on both post-belonging scores and belonging change.	Theme(s): • Mathematics self-efficacy • Past negative mathematics classroom experiences	• Mathematics affinity and expected course grades influenced belonging through their association with students' mathematics self-efficacy and past experiences. • Past mathematics experiences shaped students' current mathematics self-efficacy, which in turn affected their belonging.
Finding 3: The factor 'faculty' (*p*=0.034) had a statistically significant effect on belonging change.	• Professor's mathematical microaffirmations or microaggressions • Perception of professor as caring, supportive, and helpful • Connection with class peers	• Faculty influenced belonging change through mathematical microaffirmations (or microaggressions), demonstrations of care, and collaborative teaching approaches. • Professor's pedagogy facilitated meaningful peer connections that further fostered belonging.

Note: Explanatory Sequential Design Joint Display table adapted from Creswell & Creswell (2023, p. 241)

Expanded Integration of Quantitative and Qualitative Findings

While Table 1 offers a condensed overview of the connections between quantitative and qualitative findings, this section provides a more detailed exploration of those relationships. I expand on each integrated finding by presenting supporting evidence from both data sources. This deeper analysis highlights how the qualitative themes enrich and contextualize the statistical results, offering a fuller understanding of Black and Latina female students' sense of belonging in mathematics classrooms.

Quantitative Finding 1: Comparable Pre-, Post-Belonging, and Belonging Change Scores Across Demographic Groups

The quantitative analysis revealed only minimal differences in sense of belonging across racial and gender groups in the mathematics classrooms at this diverse institution. At the beginning of the semester, all groups reported similar pre-belonging scores on the 6-point scale (overall M=4.432, SD=0.68). Black female students (M=4.40, SD=0.71) and Latina students (M=4.37, SD=0.69) reported pre-belonging scores slightly below the overall mean. The only statistically significant difference in pre-belonging scores was between Latina students and Black male students (p = 0.026, Mean Difference =-0.24). Similarly, post-belonging scores remained relatively equivalent across groups (ranging from 4.30 to 4.56), with no statistically significant difference by race and gender after controlling for pre-belonging scores. Lastly, Black and Latina female students did not have significantly different changes in belonging compared to other groups throughout the semester (p=0.541).

These comparable belonging scores across race and gender groups differ what is typically reported in the literature. Previous research on minoritized women in STEM environments has documented significant belonging disparities based on race and gender (Johnson, 2012; Ong et al., 2018; Rainey et al., 2018). Studies have shown that Black and Latina female STEM students often report lower levels of belonging due to a lack of racial or gender diversity, feelings of isolation, and racialized and/or gendered microaggressions in STEM environments, particularly at PWIs or research institutions (Barbieri & Miller, 2021; Booker 2016; Ireland et al., 2018; Johnson et al., 2007; Johnson, 2012; Leyva et al., 2021; Solorzano et al., 2000; Rainey et al., 2018, Yosso et al., 2009). Ong et al. (2011; 2018) explained how minoritized women in STEM often face the “double bind” experiencing marginalization based on both gender and race.

Theme: Perception of Diversity and Belonging

The qualitative phase provided insights into why the findings at this institution differed from previous research. I identified the theme ‘Perception of Diversity’ as a key positive factor influencing participant’s sense of belonging in mathematics class. Interestingly, most participants (eight out of 13) expressed that diversity “didn’t really matter” in their mathematics class belonging. For example, Anela stated that that her racial or ethnic background does not “really influences my sense of belonging.” The finding that students’ racial identity was not a salient factor in their belonging is likely due to the institution’s diverse context in which participants did not feel minoritized. Moreover, participants reported no instances of racial or gender microaggressions in their mathematics classes, which may have contributed to the comparable belonging scores across groups.

However, some students explicitly stated that they valued the institutional and class diversity and that their racial/ethnic identity did influence their sense of belonging. Tyanna, for example, decided to attend this college after witnessing a Ramadhan celebration during the tour: “It just made me want to come here more because that meant it was more open… I knew I would meet a lot more different people.” Similarly, Britteny expressed that diversity was important to her: “This is a very diverse school… just seeing a whole bundh of different backgrounds, it’s pretty cool that our cultures could class together. We could all learn in a good environment.” These statements suggest that although diversity may not be a salient factor for all students, it creates an environment that supports comparable belonging scores across demographic groups. This finding aligns with Winkle-Wagner and McCoy’s (2018) research, which found that students’ perceptions of how diversity is embraced, alongside visible racial diversity on campus, shapes their feelings of inclusion and support. Moreover, interacting with diverse peers has been shown to positively influence students’ sense of belonging (Strayhorn, 2019).

Both Black and Latina female students emphasized the importance of seeing peers who shared their racial or ethnic identity in class. Britteny stated she felt a sense of belonging when other Black students were present in her classes, while Jess appreciated the diversity of her classes, which stood in contrast to the segregated environment of her hometown. Tyanna shared, “Seeing other Black women makes me feel like I belong because it gives me a small sense of community.”

For Latina students, connecting with peers who shared their cultural background and language was especially meaningful. Ana noted that class diversity was “not too important, but sometimes if there is a girl in my ethnicity, we tend to stick together in classes.” Similarly, Alexa valued “having the connection with someone” who understands “where we’re coming from.” Her description of her study group as “all Hispanic” highlights how students may naturally gravitate toward peers with shared cultural backgrounds, fostering a sense of comfort and belonging.

While intersectionality guided this study as a theoretical perspective, participants mentioned gender identity less frequently than racial or ethnic identity. Only one student, Marlina (who identified as Black and Latina) pointed to gender as a factor in her sense of belonging in class. She explained that she chose to sit next to a female peer (who later because a close study partner) because “Had she been a boy, I don’t think I would have felt comfortable enough.” This suggests that for some female students, gender may play an important role in forming peer connections in specific classroom contexts. This aligns with one of Strayhorn's (2019) core elements of belonging, that it is dependent on context, time, and various factors.

Individual Participants' Variation in Belonging Scores

While the group-level quantitative analysis revealed no statistically significant differences in belonging scores across demographic groups, examining individual participants' scores uncovered important variations that were not obvious in group means. Among the 13 participants, there was a wide range in pre-belonging (2.7 to 5.87), post-belonging (2.57 to 6), and belonging change scores (-2.2 to +1.3). These individual differences highlight that students had distinct belonging experiences shaped by a variety of factors. This individual-level analysis underscores how quantitative group-level comparisons can obscure meaningful variations in student experiences. Moreover, the qualitative analysis revealed specific influences on belonging that quantitative methods alone could not fully capture. I explore these factors further in the discussion of Findings 2 and 3, where I explain how these elements shaped students' sense of belonging in relation to my qualitative themes.

Summary of Integration of Quantitative Finding 1

The integration of these quantitative and qualitative findings deepens our understanding of how a diverse institutional context influences the sense of belonging for Black and Latina female students in mathematics classrooms. While the diverse environment appears to diminish experiences of racial or gender microaggressions, the qualitative findings reveal that diversity alone is not sufficient to cultivate a strong sense of belonging for these students (Hurtado & Guillermo-Wann, 2013). This suggests that even in classrooms where belonging scores are comparable across different groups, the ability to form supportive peer groups based on shared identities plays a critical important role in fostering positive belonging experiences. I further explore the significance of peer connections in the section titled ‘Additional insights from Qualitative Data’ section.

Connection of Quantitative Finding 1 to Research Aim

I now discuss how the integration of quantitative and qualitative findings from Finding 1 addresses the research aim: How do Black and Latina female students’ identities as female minoritized students play a role in their sense of belonging in gateway mathematics classrooms at a racially and ethnically diverse open access institution? The quantitative results revealed no significant differences in belonging based on racial and gender identity; Black and Latina female students reported comparable belonging scores to other demographic groups. The qualitative theme “Perception of Diversity” helps explain this outcome. In this diverse institutional context, racial and gender identity were not salient factors in shaping belonging for most participants.

Notably, participants reported no experiences of racial or gender microaggressions, which contrasts with studies conducted at less diverse institutions. However, some Black and Latina female students did express appreciation for seeing peers who shared their racial or ethnic identity, suggesting that diverse representation still plays a meaningful role in fostering belonging. At the same time, the variations in individual belonging scores indicate that other factors significantly influence belonging in diverse classrooms. I explore these factors further in Findings 2 and 3.

Quantitative Finding 2: Mathematics Affinity, and Expected Grades as Predictors of Belonging

The quantitative analysis revealed that mathematics affinity and expected course grades were significantly associated with both post-belonging scores and changes in belonging over the semester. For post-belonging scores, mathematics affinity (p<0.001) and expected grade (p<0.001) were statistically significant contributors within the model explaining 61.7% of variance. Similarly for belonging changes, both mathematics affinity ($p<0.001$) and expected course grade ($p=0.012$) were significant predictors with the model explaining 18.2% of variance. These findings suggest that students' self-perceptions of their mathematics abilities, which is closely tied to their mathematics self-efficacy, were more strongly associated with their sense of belonging in mathematics classrooms than race and gender.

Theme: Mathematics Self-efficacy

The qualitative theme "mathematics self-efficacy" helps explain the quantitative relationship between mathematics affinity, expected grades, and belonging. As stated in Chapter 2, mathematics self-efficacy is defined as a student's confidence in their ability to successfully perform mathematical tasks (Hackett & Betz, 1989). To categorize students as having positive or negative mathematics self-efficacy, I identified evidence of four sources of mathematics self-efficacy in each of the students' qualitative data: (1) mastery experiences, (2) social persuasions, (3) emotional and physiological states, and (4) vicarious experiences (Trujillo & Tanner, 2014; Usher & Pajares, 2009; Warwick, 2008; Zakariya, 2022).

Through the qualitative analysis, I determined that the relationship between mathematics self-efficacy and belonging was bidirectional. Students with positive mathematics self-efficacy (Alexa, Leslie, Marlina, and Tyanna) all experienced significant increases in belonging (>1 *SD*). Alexa's quote illustrates this the connection: "I feel like I belong when I can do the work and understand it as much as anyone else." Leslie similarly shared that "getting a good grade on my test" increased her sense of belonging. In contrast, students with negative mathematics self-efficacy (Ana, Faith, Julianna) typically experienced decreases in belonging (>1 *SD*). Julianna expressed how not understanding concepts made her "dread to go to class." Ana described feeling "too afraid" and "embarrassed" to admit needing help, which made her feel isolated in class. This finding aligns with previous research suggesting that academic/mathematics self-efficacy is linked with belonging in classrooms and STEM contexts (Freeman et al., 2007; Graham et al., 2023; Hoffman et al., 2021; Trujillo & Tanner, 2014; Warwick, 2008; Wilson et al., 2015; Zumbrunn et al., 2014)

Moreover, students with negative mathematics self-efficacy described being disengaged from peers and course activities. Faith explained that when she does not understand she is “more quiet” and tries to “figure it out on my own” because she does not “want to be a bother.” Similarly, Jess described withdrawing during group work when she does not understand, letting other students “kind of take over.” Their experiences explain why mathematics affinity and expected grades (measured quantitatively) predicted belonging, as students with higher mathematics self-efficacy were more likely to engage with their peers and class activities, fostering greater belonging.

Importantly, mathematics self-efficacy, like belonging, proved to be dynamic rather than static. For example, Marlina’s belonging score greatly increased (from 2.83 to 4.13, >2SD) as her mathematics self-efficacy improved: “At first, I dreaded it… but at the end I looked forward to going … I was proud of myself in the end… I didn’t feel like I was bad at math anymore.” Her experience demonstrates how improvements in mathematics self-efficacy can promote belonging, which may explain the statistically significant relationship between mathematics affinity and belonging in the quantitative analysis.

Theme: Past Negative Mathematics Class Experiences

“Past negative mathematics class experiences” is another theme that illuminates the quantitative relationships. Eight participants reported negative K-12 mathematics experiences, with five of these students also demonstrating low mathematics self-efficacy. This finding suggests a connection between past experiences and current mathematics self-efficacy, which is related to whether a student enjoys learning and doing mathematics. These negative experiences involved teachers' mathematical microaggressions, lack of individualized support, or limited peer connections. For many participants, these challenges began in elementary grades and continued throughout their education. Ana explained, "It began in elementary school and then it just continued on until I was older… I was too far behind to catch up in my math." Britteny's story particularly demonstrates how a single negative teacher experience can change a student's perception of mathematics: "I used to love math as a kid. I had a really bad teacher in 10^{th} grade… She just ruined my whole math experience." These examples help explain the quantitative finding that mathematics affinity predicts belonging.

Notably, past negative experiences did not automatically determine current belonging. Despite having negative past experiences in mathematics class, Alexa, Britteny, Jess, and Tyanna demonstrated positive belonging outcomes. Their current mathematics classes featured more positive factors and fewer negative factors affecting belonging. This finding emphasizes that mathematics instructors can promote belonging regardless of students' prior experiences, potentially disrupting negative patterns through intentional and supportive classroom practices.

Summary of Integration of Quantitative Finding 2

The themes "mathematics self-efficacy" and "past negative mathematics class experiences" provide an explanation for why mathematics affinity and expected grades were statistically significant predictors of belonging in the quantitative analysis. Mathematics self-efficacy influences how students engaged with their peers and class activities by either actively participating or withdrawing. Moreover, past negative experiences contribute to this relationship by shaping students' initial mathematics self-efficacy at the start of their college mathematics course. However, some students with negative mathematics histories were able to develop positive belonging experiences due to the presence of positive factors. My qualitative themes of mathematics self-efficacy and past mathematics class experiences explain why mathematics affinity and expected grades, rather than race and gender, were associated with belonging in the quantitative analysis.

Connection of Quantitative Finding 2 to Research Aim

The integration of both methods for Finding 2 addresses the research aim because the qualitative themes of mathematics self-efficacy and past mathematics classroom experiences revealed that students' mathematics self-efficacy (shaped by their earlier mathematics experiences) significantly influences Black and Latina female students' sense of belonging in mathematics classrooms. For the students in the study, mathematics self-efficacy appeared to be more influential than racial or gender identity in determining their classroom belonging.

While research highlights the challenges minoritized women face in STEM due to their intersectional identities (Johnson, 2011; Leyva et al., 2021; Ong et al., 2011), participants primarily discussed how their self-perception as mathematics learners shaped their belonging. This finding suggests that when students see peers who share their racial and gender identities in diverse mathematics classrooms, mathematics self-efficacy may become more salient to belonging than racial or gender identity.

However, the findings also reveal how students' past K-12 mathematics education shaped their mathematics self-efficacy. Research has demonstrated that negative mathematics experiences and outcomes often reflect systemic and institutional inequities in K-12 education that disproportionately affect minoritized students (Martin 2019; Riegel-Crumb et al., 2019; Seymour and Hunter, 2019). While the quantitative results suggest that racial and gender identity did not *directly* influence belonging in this diverse setting, there may have been an indirect influence. Specifically, participants' prior K-12 educational experiences were likely shaped by their intersectional identities as Black and Latina female students, which in turn influenced their mathematics self-efficacy and ultimately affected their sense of belonging in their current mathematics classes. This finding suggests that the salience of racial and gender identities in relation to belonging is dependent on the diversity of the educational context.

Quantitative Finding 3: Faculty Influence on Belonging Change

Faculty was a statistically significant factor (p=0.034) influencing changes in belonging in the multi-factor ANOVA model, indicating that professors have a meaningful influence on how students' belonging changes throughout the semester. However, faculty was not a significant factor (p=0.138) in the ANCOVA model for post-belonging scores. As mentioned in Chapter 3: Quantitative Results, I revised my quantitative analysis to include 'faculty' as a factor rather than a covariate after initial qualitative findings highlighted a professor's importance to student belonging. This methodological revision demonstrates an advantage of mixed methods research, in which qualitative insights can inform quantitative analysis decisions, creating a more integrated approach to understanding complex phenomena.

This finding that faculty significantly affects belonging change but not end-of-semester belonging scores was unexpected. While faculty play an important role in influencing the direction and amplitude of belonging change, more than one semester of positive belonging experiences may be necessary to significantly affect the overall average final belonging levels. Additionally, the wide variation in post-belonging scores among the 13 participants, ranging from 2.57 (SD=-2.41) to 6 (SD=2.03), suggests that faculty influence varies considerably across individual students.

Through qualitative analysis, I identified three key faculty-related themes that explain this quantitative finding: (1) professors' mathematical microaffirmations or microaggressions, (2) perception of professors as caring, supportive, and helpful, and (3) faculty impact on peer connections through their encouragement of peer collaboration. In the following sections I elaborate on how these themes enhance our understanding of faculty's influence on belonging change.

Theme: Faculty Mathematical Microaffirmations and Microaggressions

The qualitative data help explain why faculty was a statistically significant factor influencing belonging change in the quantitative analysis, particularly through the themes of faculty mathematical microaffirmations and microaggressions. My findings align with Cawley and Wilson (2023) and Su (2015) who argue that mathematical microaffirmations positively affect students' sense of belonging, while mathematical microaggressions diminish it. Of the 13 participants, five students (Alexa, Britteny, Jess, Marlina, and Tyanna) reported receiving mathematical microaffirmations from their professors. Four of these students' belonging scores increased by more than one standard deviation, while one maintained a consistently high score. These microaffirmations took various forms: validation of work ("You're doing this perfectly"), recognition of progress ("You're on the right track… good job"), and encouraging messages about the learning process ("Don't stress yourself, it's all a lot to take in. Just take it step by step"). These validating interactions strengthened both their mathematics self-efficacy and their sense of belonging.

In contrast, five students (Ana, Julianna, Jocelyn, Anela, and Marlina) reported experiencing mathematical microaggressions such as "It's easy," "This is high school stuff," or "You should already know this." Three of these students' scores decreased, with two having declines greater than one standard deviation. Anela described feeling “stupid” when her professor repeatedly announced that students should already know certain topics. These discouraging interactions also made students reluctant in seeking help. As Marlina explained, “I would never ask questions about quadratic formula, factoring, anything of that nature because I felt like it was supposed to be a given that I knew that.”

Four of the five students who received mathematical microaffirmations did not report experiencing microaggressions, suggesting that the absence of microaggressions may be just as important as the presence of microaffirmations. Marlina was the only participant reporting both types of interactions and she had the highest belonging score increase (+1.3, >2 *SD*) among all participants, despite starting with the lowest pre-belonging score. This finding suggests that mathematical microaffirmations may help counter the negative impacts of microaggressions, especially when combined with other positive factors identified in the qualitative analysis.

Theme: Perception of Faculty as Caring, Supportive, and Helpful

Extensive research has documented that faculty support and positive student-faculty interactions are crucial for fostering belonging, particularly for minoritized students (Barbieri & Miller Cotto, 2021; Bensimon, 2007; Booker, 2016; Hurtado et al., 2015; Johnson, 2012; Kirby & Thomas, 2021; Strayhorn, 2019). The theme “students’ perceptions of their professors” helps explain the quantitative finding that faculty is a significant factor in belonging change. Among the five students whose belonging scores increased more than one standard deviation, four participants described their professor as caring, supportive, or helpful. Britteny, whose score remained high, also described her professor this way.

Students valued professors who dedicated time and attention to their learning. Alexa noted her professor “went above and beyond,” and Faith appreciated how her professor “takes time out of her day to make sure we understand." How a professor responded to students' individual needs also fostered belonging. Furthermore, professors who built positive rapport with students enhanced belonging because students were able to connect to them as "human beings, not just our professors" and saw them as someone dependable. Students also appreciated professors who showed enthusiasm for teaching mathematics and used inclusive teaching practices such as welcoming questions, normalizing mistakes, and re-explaining "easy" concepts. Alexa explained how her professor's passion for mathematics "reciprocated off of us," while Britteny appreciated that her professor did not make her feel bad "if I didn't understand something." These findings were consistent with results from Zumbrunn et al.'s (2014) study in which students with higher belonging scores also perceived their instructor as more passionate and caring in the classroom.

On the other hand, four students (Ana, Anela, Joselyn, and Kayla) described their professors as uncaring, unsupportive, or unhelpful. Ana's belonging score decreased significantly while the other three maintained low scores throughout the semester. Students perceived their professors negatively when professors failed to develop rapport, provided inadequate support, or appeared condescending. Ana felt like "an outsider" in her mathematics class, while Anela and Kayla struggled to keep up with professors who they felt did not explain concepts thoroughly. These negative perceptions led students to disengage with their peers, professors, and class activities, and made them reluctant to ask questions for fear of humiliation.

An unexpected finding was that three students (Imani, Faith, and Julianna) described their professors as caring although their belonging scores decreased significantly. This finding suggests that professor support alone, while necessary, may be insufficient when other negative factors are present or other positive factors are lacking. Faith expressed that her professor "*tried* to make us feel like we all belong," suggesting that her professors' efforts was not enough for her to experience strong belonging. Similarly, while Julianna's professor showed care through encouraging words, they did not provide the practical academic support she needed. This finding aligns with Zumbrunn et al.'s (2014) research which indicated that students' belonging requires both academic and social support from professors. These experiences underscore that faculty support is multidimensional, as they must demonstrate care and provide accessible and concrete assistance that address students' diverse academic needs.

Theme: Faculty Impact on Peer Connections through Encouragement of Collaboration

Research has established that collaborative peer learning enhances students' sense of belonging in class and faculty play a key role in structuring these collaborative opportunities (Hurtado & Carter, 1997; Johnson, 2012; Lock et al., 2008; Museus et al. 2011; Ong et al., 2011; Prasad, 2016; Rainey et al., 2018; Strayhorn 2019; Zumbrunn et al., 2014). The qualitative data demonstrates how faculty influenced belonging by either encouraging or limiting peer connections, further explaining why faculty was a significant factor in belonging change. Five participants (Alexa, Britteny, Imani, Jess, and Leslie) reported experiencing peer interaction opportunities in class. Three of these students' belonging scores increased more than one standard deviation, while Britteny's high belonging score slightly increased.

Their professors used various collaborative strategies, including group work at white boards, arranging problem solving in groups, and encouraging students to "ask each other so we can help each other." These faculty-created structures fostered classroom communities in which students felt comfortable relying on their peers. Imani appreciated seeing concepts "from a classmates' perspective," and Leslie found that "working with them helped me learn." Jess noticed that "after a while we learned how each other's minds work so it was easier to work with each other." Group interactions created more intimate safe spaces within the classroom for asking questions without judgement. Alexa explained that in her peer group, "if one person doesn't really get it, everybody else could help that person."

However, seven students (Ana, Anela, Joselyn, Julianna, Kayla, Marlina, and Tyanna) reported limited collaboration in their classes. Among these students, two students' belonging scores decreased, and three maintained low scores. Marlina and Tyanna's belonging scores increased despite limited peer collaboration, possibly due to other positive factors such as positive perception of professor and strong mathematics self-efficacy (and in Marlina's case, peer connections). Most of these participants described lecture-based classes with minimal peer interaction, unclear group work expectations, and participation dominated by select students.

These qualitative data highlight the importance of faculty's role in facilitating or hindering peer collaboration through their pedagogical approaches. Faculty who structured collaborative activities enhanced belonging by creating opportunities for meaningful peer relationships, while those relying primarily on passive approaches such as lectures restricted this development. These differences in classroom experiences reveal why faculty was a significant factor of belonging in the quantitative analysis, as their pedagogical decisions directly shaped students belonging experiences. As Hurtado et al., (2015) emphasized, faculty play a critical role in creating inclusive class environments and establishing conditions for belonging (Hurtado et. al., 2015).

Summary of Integration of Quantitative Finding 3

I integrated the quantitative and qualitative findings to explain why faculty was a significant factor in belonging change. The three themes illustrate how faculty influence belonging through mathematical microaffirmations or microaggressions, demonstrations of care and support, and classroom structures that either promote or hinder peer connections. This suggests that while faculty impact is significant, the wide variation in post-belonging and belonging change scores indicates that belonging is a complex construct related to other factors such as mathematics self-efficacy, past mathematics class experiences, perception of diversity, and peer relationships.

Connection of Finding 3 to Research Aim

Finding 3 addresses the research aim by revealing critical faculty-student relationship dynamics that influence Black and Latina female students' sense of belonging in diverse mathematics classrooms. Participants did not explicitly connect their racial or gender identities when describing faculty interactions, which further supports Finding 1, that racial identity was less salient in this diverse setting. The qualitative themes of mathematical microaffirmations, demonstrations of care, and facilitation of peer collaboration point to essential faculty characteristics that promote belonging in a diverse setting. How professors made these Black and Latina female students feel in class, whether valued, capable, encouraged, acknowledged, and included, significantly impacted their belonging by fostering deeper positive connections between students and with the professor.

Additional Insights from Qualitative Data

Theme: The Critical Role of Peer Connections

Peer connections were briefly discussed in Finding 3 as they related to faculty influence. However, the qualitative data revealed that peer relationships played a more profound role in students' mathematics classroom belonging, a role not captured in the quantitative findings, further illustrating the benefits of mixed methods designs. The significance of peer connections aligns with Strayhorn's (2019) model that characterizes belonging as relational and contextual.

In this section, I explore how peer connections impact Black and Latina female students' sense of belonging in multiple ways, independent of faculty influence. The participants actively formed peer connections that functioned as academic, emotional, and social support systems, serving as buffers against negative belonging factors.

An important finding from the qualitative data was that students took an active role in creating a sense of community when class structures were insufficient. Six participants (Alexa, Anela, Britteny, Leslie, Marlina, and Joselyn) described taking the initiative to develop peer connections that significantly enhanced their belonging. Leslie explained starting a group chat after struggling with homework: "I felt like I was part of something to be able to ask questions if I needed help." Similarly, Marlina and Joselyn formed study groups when they recognized that other peers were also struggling.

However, there were notable differences in how easily students formed these connections based on the class structure. In classes where faculty encouraged collaboration, students like Alexa, Britteny, and Leslie were able to develop multiple peer relationships more easily. In contrast, in classes with limited collaboration, students like Marlina and Joselyn had to be more deliberate in making connections, typically forming one or two peer relationships. This finding suggests that while it is important for students to actively form peer connections, faculty can design instruction and establish classroom norms to make this process easier. This idea is consistent with other researchers advising faculty to structure productive peer interaction and group work to promote belonging (Rainey et al. 2018; Zumbrunn et al., 2014).

Peer connections functioned as academic, emotional, and social support systems that collectively fostered belonging. Students helped each other with coursework when professors were unavailable or when they felt uncomfortable asking professors directly. For many participants, peers provided crucial emotional support. Alexa described her class peers giving her a “sense of security” and Britteny characterized her class as a “big family” that shared encouraging messages through group chat. This social support helped students navigate through challenges; as Marlina explained, “Studying with her, I didn’t feel alone in the class.”

Peer support strengthened belonging as the relationships extended beyond classroom, with students “hanging out” after class and forming friendships that made the class “more than just an academic space,” as Britteny stated. These findings are consistent with research emphasizing the ways in which students’ belonging develops through academic, emotional, and social connection via peer support (Hoffman et al., 2002; Johnson et al., 2007, Strayhorn, 2019). While previous research identified peer connections as important for minoritized students in STEM, my findings extend this understanding by illustrating how peer connections function to enhance belonging in diverse mathematics classrooms.

An important aspect of peer connections is that they served as buffers against negative belonging factors. None of the four students (Ana, Faith, Imani, Julianna) whose belonging score decreased by more than one standard deviation reported feeling connection with their peers. However, three of those students (Faith, Imani, and Julianna) described their professors as caring. This suggests that for some students, professor support is necessary but not sufficient to maintain belonging without peer connections.

Kayla’s experience illustrates this buffering effect. She initially had two friends in class who made her not feel as “overwhelmed,” but when they withdrew from the class her belonging decreased: “I just felt more and more alone… and like I don’t think I can do this.” In contrast, Anela, and Joselyn, who described their professors as unsupportive, still managed to develop peer connections and experienced relatively little change in their belonging scores. This finding suggests that positive peer relationships (even a single one) may buffer against negative belonging experiences and can also help students persist when they face challenges in class.

It is important to note that some participants deliberately refrained from developing connections with their peers, despite the benefits of belonging. For example, Faith who had low mathematics self-efficacy, explained that she chose not to collaborate with her peers because, "I was doing bad in the class… my grade is not good, so I don't want to teach them wrong." This suggests that appropriate institutional or instructor support may be necessary to facilitate peer connections for some students.

Connection to Research Aim

The theme of "Peer Connections" addresses the research aim by revealing how Black and Latina female students manage belonging through peer connections in mathematics classrooms. While the quantitative findings suggest that racial identity was less salient in this diverse setting, the qualitative data on peer connections implies that the way some participants developed these relationships may still have been influenced by their minoritized identities, such as forming peer groups with other Latinx students in Alexa's case and forming study groups with female peers in Marlina and Anela's case.

Their experiences indicate that in diverse classrooms, being able to see and connect with peers who share racial/ethnic or gender identities mattered for Black female and Latina students' sense of belonging. Furthermore, many participants took an active role in forming supportive peer relationships even in classes where collaboration was not a norm, serving as a buffer against negative belonging factors for some students. My findings corroborate other research that emphasizes the importance of peer interactions and relationships, especially for minoritized female students in STEM field (Espinosa 2011; Johnson, 2012; Ong et al., 2011).

Practical Implications for Gateway Mathematics Class Faculty

This study revealed that students across demographic groups reported similar levels of belonging within a diverse institutional setting. However, the qualitative findings suggest that faculty should not assume that diversity alone fosters inclusion and belonging. Building a supportive environment where students feel they belong requires intentional, sustained effort throughout the semester. As Strayhorn (2019) emphasized, students' sense of belonging must be continuously nurtured. Furthermore, Strayhorn warned that when educators neglect students' need to belong, they risk contributing to students' struggles. In this section, I offer some practical implications for mathematics faculty, with a particular focus on supporting Black and Latina female students' sense of belonging in gateway mathematics courses at a diverse minority-serving institution. However, these recommendations may also be beneficial belonging among all students in similarly diverse educational contexts.

Address Mathematics Self-Efficacy as a Key Belonging Factor

Finding 2 revealed a strong connection between mathematics self-efficacy and students' sense of belonging. Faculty should implement practices that enhance students' confidence in their mathematics abilities. Many participants with negative mathematics self-efficacy felt isolated in their classes and believed they were "the only one who's mathematically behind" or "the only one struggling." Faculty can help normalize struggle as a natural part of learning by sharing their own past challenges with mathematics. Additionally, they can design low-stakes assignments and assessments that include opportunities for revision. Incorporating creative opportunities for students to express their understanding, through discussions, projects, and presentations, can also engagement and confidence. Faculty should provide individualized attention both during and outside of class to offer not only academic support but encouragement.

It is especially important to support students demonstrating low mathematics self-efficacy early in the semester, as this study found that these students struggled to develop a sense of belonging without intentional, targeted support.

Develop Awareness of Mathematical Microaffirmations and Microaggressions

In Finding 3, I discussed the significant impact of professors' mathematical microaffirmations and microaggressions on students' sense of belonging. Faculty professional development programs should focus on helping instructors understand, recognize, and avoid mathematical microaggressions such as "this is high school stuff" or "you should already know this," which participants reported as undermining their sense of belonging and discouraging them from asking. At the same time, faculty should be encouraged to intentionally and consistently use microaffirmations that validate students' efforts, contributions, and progress. Participants noted that these affirmations enhanced their sense of belonging. According to Demetriou et al. (2023), conscious use of microaffirmations can help reduce the use of microaggressions. Faculty may also benefit from participating in faculty peer observation groups focused on classroom communication patterns, which can help them reflect on and improve their use of both microaffirmations and microaggressions.

Establish Clear Office Hours and Support Structures

While some students greatly benefited from regularly attending office hours, other students were unsure when or even if their professors were available outside of class. Faculty should clearly establish and consistently communicate their office hours, particularly to first-year students who may be unfamiliar with this resource. Offering both in-person and virtual office hour options can increase accessibility and encourage broader participation. Instructors can explain the purpose of office hours, refer to them frequently during class, and consider encouraging students to attend at least once early in the semester. The study found that students who perceived their professors as taking time to help them in and outside of class reported a stronger sense of belonging.

Intentionally Structure Peer Collaboration

Additional insights about peer connections suggest that faculty should design classroom activities that foster meaningful student relationships, rather than assigning group work without clear expectations. Participants described non-collaborative classes as primarily lecture-based, lacking clear classroom norms for group work, and dominated by a few students, all of which diminished their sense of belonging. To promote equitable participation, faculty should establish classroom norms for collaboration within the first weeks of the semester, in partnership with students. Instructors can allow students to choose their own groups at times, while also intentionally forming groups to encourage interaction among diverse peers. Research has shown that interactions with diverse peers - and not just the presence of diverse peers - contributed to sense of belonging for all students (Johnson et al., 2007; Locks et al., 2008; Strayhorn, 2019).

As reflected in the students' experiences, structured collaboration created spaces where they felt comfortable asking questions and making mistakes. However, faculty should recognize that some students, especially those with negative mathematics self-efficacy, may require more encouragement to participate. Digital platforms such as group chats can also support peer connections, as some students reported that these tools significantly enhanced their sense of belonging by providing academic and emotional peer support outside of class time.

Support First-Year Students Through their Transition and Challenges

The study revealed that some participants, particularly first-generation students, struggled with the transition to college-level mathematics coursework due to unfamiliarity with college norms. Gateway mathematics faculty should be especially attentive to the needs of first-year students by providing explicit guidance on navigating academic systems and available campus resources. Even small misunderstandings, such as confusion about exam make-up policies, can significantly discourage students and impact their belonging. Faculty should also focus on creating supportive classroom environments from the very beginning of the semester to reduce withdrawal rates. Student attrition not only affects those who leave but also negatively impacts the sense of belonging among the students who remain.

These practical implications underscore that belonging is shaped by intentional pedagogical practices. By implementing these recommendations, mathematics faculty can create more welcoming and encouraging environments in which Black and Latina female students, and all students, can develop a stronger, more sustained sense of belonging.

Limitations of the Study

The explanatory sequential mixed methods design was appropriate for this study's research aim. However, in this section, I acknowledge several limitations.

In the quantitative phase, I used the Math Sense of Belonging scale developed by Good et al. (2012), which was originally validated for a calculus course at a highly selective university with less racial diversity. As a result, this instrument may not have fully captured the aspects of belonging experienced by students in college algebra or precalculus courses at a diverse, open-access, minority-serving institution.

A significant limitation was the substantial attrition between the pre-survey (N=1,136) and post-survey (N=639), with only 56% of initial participants completing both surveys. While some students chose not to participate in the post-survey, this decrease largely reflects the high withdrawal rates typical in gateway mathematics courses at this institution. Students who withdrew or stopped attending class likely had lower sense of belonging, and their absence from the post-survey may have skewed the results toward students with more positive belonging experiences. The relatively high mean scores on both pre- and post-surveys (around 4.4 on a 6-point scale) suggest that students who completed the semester had relatively high belonging scores. However, these findings cannot be generalized to students who withdrew or stopped attending.

In the statistical analysis, the multi-factor ANOVA model for belonging change was statistically significant but accounted for only 18.2% of the variance in belonging difference scores. This suggests that other unmeasured factors likely influenced changes in belonging. Additionally, while the faculty variable was significantly associated with belonging change (p=0.034), it included 32 different instructors with varying numbers of students and classes, introducing variability that may not have been fully accounted for.

In the qualitative phrase, I obtained rich data through one-time interviews but was unable to capture students' sense of belonging mid-semester. Furthermore, I conducted interviews at the end of the semester when students already had an idea of what their final grades were, which may have introduced recall bias. The sample size for the qualitative phase (N=13) was sufficient for exploring belonging experiences but limits the generalizability of the findings. There may also be self-selection bias as participants who volunteered for interviews may have stronger (positive or negative) opinions about their class experiences and instructors. In addition, as the sole researcher designing, collecting, analyzing, and integrating both quantitative and qualitative data, the interpretation of findings may reflect my own biases, perspectives, and experiences. The absence of member checking may limit the objectivity of the analysis.

The study was conducted at a single, open-access, diverse, public minority-serving institution, which may not reflect the experiences of Black and Latina female students at institutions with different student demographics or in different geographic regions. The finding that race and gender were not significant factors of belonging may not be generalized to less diverse settings. Moreover, the focus on gateway mathematics courses may limit the applicability to more advanced mathematics courses. All participants were enrolled in in-person mathematics courses during a traditional 15-week semester, which may not reflect the experiences of students in online or hybrid formats that have become more common since the COVID-19 pandemic.

Directions for Future Research

In this section, I discuss several directions for future research that could deepen our understanding of students' sense of belonging in mathematics classrooms.

First, researchers could investigate which faculty practices most effectively foster belonging by identifying instructors whose students demonstrated the greatest increases or decreases in belonging over time. Incorporating classroom observations and faculty interviews would provide insight into professors' biases, behaviors, and beliefs on belonging, especially since as Hurtado et al. (2015) noted, faculty values are rarely assessed. It would also be valuable to examine how classroom norms are established in environments that successfully foster belonging. This approach aligns with calls from other scholars for more research on how effective pedagogical practices contribute to student belonging (Kirby & Thomas, 2021; Zumbrunn et al., 2014). It also responds to Strayhorn's (2019) assertion that we have yet to fully understand which experiences most effectively promote the belonging outcomes we desire for students.

Second, future research should explore the experiences of students who withdraw or stop attending mathematics courses, particularly in relation to their sense of belonging. As noted in the limitations, this study did not capture post-survey data from students who withdrew. Faculty often hold assumptions about why students withdraw, frequently from a deficit perspective. However, one of the theoretical perspectives guiding this study, Cook-Sather's (2002) concept of Authorizing Student Perspectives, emphasizes that understanding students' own perspectives is essential to making sense of any complex educational phenomena.

To better understand these perspectives, future research could involve interviewing both students who withdraw and the faculty who teach them, focusing on the views regarding the causes of attrition and how it relates to belonging. This approach could support the development of more effective, student-centered retention strategies. As Faircloth et al. (2021) argued, understanding student perspectives is key to addressing the persistent issue of low belonging and identifying what can be done to foster a stronger sense of belonging before students disengage and withdraw.

Finally, a third direction for future research is to expand the population and context to include students with disabilities and LGBTQ+ students, as these groups may face unique challenges to belonging in mathematics classrooms. This aligns with the theoretical perspective of intersectionality, which claims that social issues are rarely the result of a single identity dimension, such as race or gender, but rather emerge from the interaction of multiple identities that shape individuals' distinct experiences (Strayhorn, 2013).

In my study, disability status was not included in the quantitative analysis, although two participants disclosed learning disabilities during interviews. Additionally, students who did not identify as male or female were excluded due to the focus of my study and the small sample. Future research should include these populations to understand their belonging experiences.

In terms of context, future studies could also examine belonging in elementary mathematics education courses, higher-level mathematics courses, as well as in online and hybrid learning environments. These formats have become more common and may present distinct belonging-related challenges. Mixed methods approaches incorporating additional intersectional identities and contextual variables would offer a more comprehensive understanding of belonging across diverse student populations and educational settings.

These research directions would help address existing gaps in the literature on mathematics classroom belonging and build upon the findings of this study. By exploring these factors across broader populations and contexts, researchers and educators can develop more targeted interventions and institutional structures that foster inclusive mathematics learning environments, where all students can develop a strong sense of belonging.

Conclusions

This mixed methods study examined the sense of belonging of Black and Latina female students in gateway mathematics classrooms at a diverse, minority-serving institution. The integration of quantitative and qualitative findings revealed that race and gender were less salient than other factors in shaping students' belonging experiences. Instead, mathematics self-efficacy emerged as an important influence. Faculty also played a crucial role through their use of mathematical microaffirmations and microaggressions, demonstrations of care and support, and facilitation of peer connections. Qualitative findings further highlighted the importance of peer relationships, with students often taking initiative to build these connections even when collaborative classroom structures were lacking.

This study's context at a single, open-access, diverse, public minority-serving institution represents a strength of the research. The setting provides critical insights into Black and Latina women's experiences in mathematics in a racially diverse classroom, a context that has been underexplored in belonging research. The institution's diversity allowed for examination of belonging experiences within a racially and ethnically heterogeneous classroom environment, which may closely reflect the changing demographics of higher education. Focusing on the classroom level is valuable as it moves beyond institutional or departmental factors to examine daily experiences that shape students' sense of belonging in mathematics courses.

This study contributes to the literature by emphasizing the contextual and multidimensional nature of belonging within mathematics classrooms. Importantly, it centers students' voices, an element often missing in quantitative belonging studies. In contrast to studies conducted in less diverse institutions that reported racial or gender identity as central to belonging, this study suggests that in diverse classroom settings, other factors may be more influential for Black and Latina female students. Mathematics self-efficacy, faculty-student interactions, and peer relationships were identified as the most significant contributors to belonging. Moreover, while extant research tends to focus on negative influences, this study also identified positive factors that support belonging. Additionally, the finding that positive factors can buffer against negative ones extends our understanding of how belonging develops through complex, interacting pathways.

The practical implications of this study underscore that fostering belonging is not a one-time event but requires intentional, ongoing, and diverse approaches. Mathematics faculty must adopt and implement practices that enhance students' mathematics self-efficacy, use mathematical microaffirmations while avoiding microaggressions, establish clear support structures, and facilitate meaningful peer connections. These practices help create classrooms where students feel seen, supported, and valued. As Alexa shared: “You’re not in it by yourself. You’re going to have someone else to help you along the way…not just being there because you have to but being there because you feel like you’re needed there.” By implementing these comprehensive approaches, mathematics classrooms can become spaces of belonging, not only for Black and Latina female students, but for all students.

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APPENDICES

Appendix A: Demographic Questionnaire

1. What is your 900#? ______________________________
2. What is your email address? ________________________________
3. This course is
   - o Math 1111 College Algebra with Support
   - o Math 1111 College Algebra
   - o Math 1113 Precalculus

4. What is the section number of this math course? _______________________
5. To which gender do you most identify?
   - o Female
   - o Male
   - o Other/Prefer not to say

6. Which of these options best describes your race/ethnicity?
   - o American Indian/Alaskan Native
   - o Asian/Asian American
   - o Black/African American
   - o Hispanic/Latinx
   - o Native Hawaiian/Pacific Islander
   - o White
   - o Other: ______________________________

7. What is your age? ___________
8. Which option best describes your current employment status?
   - o I have a full-time job.
   - o I have a part-time job.
   - o I am currently not working.

9. Which option best describes your financial aid status?
   - o I use financial aid to pay for all my tuition and fees.
   - o I use financial aid to pay for part of my tuition and fees.
   - o I do not use financial aid to pay for my tuition and fees.

10. Which best describes the level of education of your parents/guardians?
    - o Both of my parents/guardians have a bachelor’s degree.
    - o One of my parents/guardians has a bachelor’s degree.
    - o Neither of my parents/guardians has a bachelor’s degree

11. What is your major?
    - o Dual Enrollment
    - o Biology

- Chemistry
- Environmental Science
- Exercise Science
- Information Technology
- Mathematics
- Other ___________________________________

12. How many college credit hours have you taken so far?
    - 0-15
    - 16-30
    - 31-45
    - 46-60
    - 60 or more

13. How many credit hours are you currently enrolled in this semester?
    - 1-4
    - 5-8
    - 9-12
    - 13 or more

14. What is the highest level of math course offered at your high school?
    - Algebra
    - Geometry
    - Precalculus
    - Calculus
    - AP Calculus
    - Other: ______________________

15. What is the last math course you took in high school?
    - Algebra
    - Geometry
    - Precalculus
    - Calculus
    - AP Calculus
    - Other: ______________________

16. What was your previous math course in college?
    - This course is my first math course in college.
    - Math 1113 Precalculus
    - Math 1111 College Algebra
    - Math 1101*/0999A Math Modeling
    - Other: ______________________________

17. What grade did you earn in your most recent math course (either in high school or college)?
    - A
    - B
    - C
    - D
    - F

- Withdrew

18. What grade do you expect to earn in this math course?
    - A
    - B
    - C
    - D
    - F

19. Please choose one response to the following statement: *I enjoy learning and doing math.*
    - Strongly disagree
    - Somewhat disagree
    - Neither agree nor disagree
    - Somewhat agree
    - Strongly agree

Appendix B: Sense of Belonging Scale

Mathematics Sense of Belonging Scale (adapted from Good et al., 2012)

Directions: Today I have some questions I would like you to answer about your experiences with college algebra. I would like you to consider your membership in the college algebra class. Please respond to the following statements based on how you feel about this course and your membership in it. There are no right or wrong answers to any of these statements; we are interested in your honest reactions and opinions. Please read each statement carefully and indicate the number that reflects your degree of agreement.

	Strongly Disagree					Strongly Agree
	1	2	3	4	5	6

When I am in my college math class….

1. I feel that I belong in the class.
2. I consider myself a member of this class.
3. I feel like I am part of the class.
4. I feel a connection with the class.
5. I feel like an outsider.
6. I feel accepted.
7. I feel respected.
8. I feel disregarded.
9. I feel valued.
10. I feel neglected.
11. I feel appreciated.
12. I feel excluded.
13. I feel like I fit in.
14. I feel insignificant.
15. I feel at ease.
16. I feel anxious.
17. I feel comfortable.
18. I feel tense.
19. I feel nervous.
20. I feel content.
21. I feel calm.
22. I feel inadequate.
23. I wish I could fade into the background and not be noticed.
24. I try to say as little as possible.
25. I enjoy being an active participant.
26. I wish I were invisible.
27. I trust the testing materials to be unbiased.
28. I have trust that I do not have to constantly prove myself.
29. I trust my instructors to be committed to helping me learn.
30. Even when I do poorly, I trust my instructors to have faith in my potential.

Appendix C: Instructions for Mathematics Autobiography

Mathematics Autobiography

You are asked to reflect on your own experiences in mathematics classrooms as a student and how those experiences impacted your sense of belonging in mathematics classrooms. Please address the following questions.

- What do you remember about learning math in elementary and middle school?
- What about more recently (in high school and college)?
- How do you feel about math? How have your feelings changed over time?
- What was a high point in your math experience? What happened and who was involved?
- What is the single greatest challenge that you have faced in math? How have you faced and dealt with that challenge?
- What did your teachers do to make you feel accepted or valued in the math classroom?
- How did your teachers make you feel uncomfortable or like you don’t matter in the math classroom?
- In your previous math classrooms, how did your classmates impact your sense of belonging?
- What makes you feel like you belong in a math classroom?
- What makes you feel like you don’t belong in a math classroom?
- Were most students in your math classes of the same ethnicity, race, gender, or linguistic or socioeconomic background as you? Did this change over time? If so, how?
- How would you define belonging?

Appendix D: Semi-structured Individual Interview Protocol

Participant:
Date: Time:
Place:
Remember to hit RECORD!
Opening Questions:

1. Tell me a little bit about yourself. How would you describe yourself to others?
    a. What are your passions?
    b. You stated that your major is __________. What career(s) are you trying to pursue?
    c. How did you like your math class? What was it like for you?

Perception of classroom environment

2. What was the classroom environment like? How comfortable did you feel asking questions?
3. How would you describe a typical class meeting for your college algebra/precalculus course?
    a. What was the instruction like?
    b. What were the class activities like?
    c. What were the assignments like?
    d. What were the tests like? In what ways did you prepare for tests?
4. In what ways did you participate during your math class meetings?

Perception of faculty support

5. What was your mathematics professor like?
6. In what ways did you feel encouraged/discouraged by your instructor?
7. What kinds of interactions with faculty helped you feel that you are valued in the classroom? Can you think of a specific example? (Ask the converse)
8. What kind of outside interactions did you have with your instructor?
9. What could the professor have done differently?
10. What is the gender or ethnicity of your professor? How important is that for you?

Perception of peer support

11. What kinds of interactions with your classmates helped you feel that you matter in the classroom? Can you think of a specific example? (Ask the converse)
12. What kind of outside interactions did you have with your classmates?
13. What was the gender/race make-up of the class? How important is class diversity for you?

Perception of challenges

14. What has been the hardest part of being a student in this math class? How did you overcome that challenge?

15. Were there instances that you were discouraged to the point that you considered withdrawing from the course? What were the circumstances and why did you decide to persist?
16. Do you have outside responsibilities?

Perception of support systems

17. What support systems help you persist and overcome challenges in college algebra/precalculus? Emotional support?
18. Have you tried using the AEC?

Perception of future math course:

19. What would your ideal math class and professor be like?

Perception of sense of belonging:

20. In what ways did you feel that you belonged in your math classroom?
21. Can you think of a time in this class when you felt like you didn't belong? (ask if not addressed yet)
22. I've noticed that your sense of belonging increased/decreased from the beginning to the end of the semester based on your pre and post surveys. What do you think contributed to that change?
23. What could have made you feel a higher sense of belonging at the end of the semester?
24. What could the professor have done differently to increase your sense of belonging?
25. How has your sense of belonging impacted your progress and success in this course?
26. How would you describe your race/ethnicity?
27. How do your gender and racial/ethnic identity influence your sense of belonging in your class?

Concluding question:

28. Is there anything else you would like to share about your experiences in college algebra/precalculus?

Check math autobiography. Ask follow-up questions or remind them to complete if not completed.

Appendix E: IRB Forms

UNIVERSITY OF GEORGIA

Tucker Hall, Room 212
310 E. Campus Rd.
Athens, Georgia 30602
TEL 706-542-3199 | FAX 706-542-5638
IRB@uga.edu
http://research.uga.edu/hso/irb/

Human Research Protection Program

EXEMPT DETERMINATION

September 18, 2023

Dear Amy Ellis:

On 9/18/2023, the Human Subjects Office reviewed the following submission:

Title of Study:	Sense of Belonging of Minoritized Female STEM Students in Introductory Mathematics Classes: A Mixed Methods Study
Investigator:	Amy Ellis
Co-Investigator:	Sarah Park
IRB ID:	PROJECT00007829
Funding:	None
Review Category:	FLEX Exempt 7

The local IRB review has been accepted.

We have determined that the proposed research is Exempt. The research activities may begin 9/18/2023.

Since this study was determined to be exempt, please be aware that not all future modifications will require review by the IRB. For more information please see Appendix C of the Exempt Research Policy (https://research.uga.edu/docs/policies/compliance/hso/HRP-033-ExemptResearch.pdf). As noted in Section C.2., you can simply notify us of modifications that will not require review via the "Add Public Comment" activity.

A progress report will be requested prior to 9/18/2028. Before or within 30 days of the progress report due date, please submit a progress report or study closure request. Submit a progress report by navigating to the active study and selecting Progress Report. The study may be closed by selecting Create Version and choosing Close Study as the submission purpose.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103).

Sincerely,

Tammy Andros, Compliance Professional
Human Subjects Office, University of Georgia

[redacted]

Institutional Review Board

Memorandum of Approval

RESEARCHER(S): Sarah Park

FROM: IRB Committee

RE: IRB Proposal # 17466

DATE: April 26, 2023

Committee Action: Accepted

Study Title: Sense of Belonging of Black and Latina Female STEM Students in Introductory Mathematics Classes

Your proposal has been reviewed under the review process detailed in the policies and procedures of the Institutional Review Board.

We are pleased to inform you that your proposal has been approved. We determined further that your study is approved for a period of three (3) years and does not need to be renewed annually, but you are responsible for informing the IRB of **any changes** to the study. Additionally, you need to submit a **completion report** at the end of the study. Both of these can be done by emailing the IRB Chair with the appropriate forms located on the [redacted] IRB website. [redacted]. Finally, please make sure to use student codes to replace student names/numbers to protect students' identity.

Approved Procedure (s)

Quantitative measures:

- Final grades and attendance rates in College Algebra will be requested directly from instructors whose students participated in this study.

- Students will complete the following:

(1) a brief questionnaire that asks for their age, gender, ethnicity, major, year, first-generation status, and full/part-time status at the beginning of the semester;

(2) an adapted version of the Sense of Belonging Scale. Students will be asked to complete the Belonging Scale the beginning and end of the semester (Pre- and post-surveys). The Belonging Scale includes items such as "I feel a connection with the class", "I feel like an outsider", and "I feel accepted." The scale will also include open response items that ask students to describe positive or negative experiences of sense of belonging in the college algebra classroom.

Qualitative measures:

- Brief Mathematics Autobiography: As college success is connected with past educational experiences in K-12, ten participants will be asked to write a short math autobiography about major experiences that promoted or discouraged their feelings of belonging in mathematics classes.

- Individual Interviews: I will choose a purposive sample of ten students (five Latina and five Black women, from both high and low belonging groups from pre- and post-survey data and open responses) across various college algebra sections to gain further insight into their experiences using a phenomenological approach. The semi-structured interviews will be conducted using an interview protocol at the end of the semester and last between 60-90 minutes.

Approved Document (s)

Student Interview Questions 4-13-23.docx

Math Sense of Belonging Scale-_4-13-23.docx

Student Demographic Questionnaire 4-13-23.docx

Student-Consent-Form_Belonging_Sarah Park_4-13-23.docx

Adverse Events:

Any serious or unexpected adverse event must be reported to the IRB Chair within 48 hours.

Amendments:

Any changes to the protocol, including changes in the research design, equipment, personnel, or funding, must be approved by the IRB committee before they can be initiated.

Mandatory Training for all Researchers:

All study personnel must complete training in human subject research. Training can be completed through the NIH or CITI. See the IRB website for details.

http://www.ggc.edu/faculty-and-staff/irb/

Consent Form Storage and Final Report

You are required to maintain all consent forms in a secure location and to provide a final report of the research to the IRB upon completion of the project.

Research at Other Campuses

Research activities at an External Site may only begin once written authorization from an authorized representative of that External Site has been received and uploaded to the IRB Portal. Please submit the authorization/permission (by editing the current application) when this becomes available.

Appendix F: Consent Forms

Participant Informed Consent

Title: Sense of Belonging of Minoritized Female STEM Students in Introductory Mathematics Classes
Investigator (s): Sarah H. Park
Please read the following consent form. By signing, you agree to all terms and conditions of the research.

1) As an adult over 18 years of age, I give my consent for Sarah Park, to involve me in their study titled: Sense of Belonging of Minoritized Female STEM Students in Introductory Mathematics Classes

2) **Purpose of the Study**: The purpose of this study is to examine students' sense of belonging and experiences in their college algebra or precalculus classes.

3) **Procedures to be followed**: Following this informed consent, I will be asked to complete a demographic questionnaire, pre- and- post surveys on my perceived sense of belonging in College Algebra. Demographic information and sense of belonging scores will be used, but my identity will remain anonymous. Based on the survey results, a select number of students may be asked for follow-up interviews.

4) **Duration/Time**: This study will last approximately one semester.

5) **Discomforts and Risks**: I understand that this experiment does not pose any risks to me beyond those encountered in everyday life.

6) **Benefits**:

    a) While there are no benefits to the participants to this study, results will contribute to a growing research base of students' sense of belonging in the field of undergraduate mathematics education.

    b) The benefits to society and education include contributing to an understanding of how to better develop classroom structures and pedagogies that foster rather than hinder students' sense of belonging in their chosen STEM field. The study also has the potential to improve undergraduate mathematics education by informing the growing body of literature exploring how educators can best foster sense of belonging and support female minoritized students' aspirations and success in STEM classrooms and departments to increase their participation in STEM careers.

7) **Statement of Confidentiality**: I understand that no identifying information will be used in any report describing my behavior or responses and that only the students named above and their professor will be informed of my participation in this activity (unless I ask to have a third party informed for proof of completion). This means that I will be randomly assigned an identification number that will be known only to the experimenter. My name or other identifying information will not be requested during the survey. My informed consent sheet, the only document that has my name, will be stored separately from my data.

8) **Right to Ask Questions**: Participants have the right to ask questions and receive appropriate responses to those questions. If you have questions about this study, please contact Sarah H. Park at [redacted]. For questions concerning your rights as a research participant, contact [redacted] (telephone: [redacted]).

9) **Compensation**: Participants may receive the satisfaction of knowing that they have helped contribute to science. Based on the survey results, 8 to 12 students may be asked to complete a math autobiography and be interviewed. Interview participants will be compensated $15 for their time.

10) **Voluntary Participation and Right to Withdraw**: I understand that I have the right to revoke this consent at any time. Moreover, even if I choose to continue to participate in an interview or other activity, I may decline to answer some questions or perform some tasks. The researchers guarantee that if I refuse to participate, there will be no penalty, no retribution, no impact on course grades, and no loss of benefits.

11) **Identifiable private information**: This research involves the collection of identifiable private information and I agree that identifiers may be removed, and **de-identified** information **may be** used or shared for future research without additional informed consent from me. Consent forms will be kept in a sealed envelope in a locked cabinet in an office until final grades are posted.

12) **Broad Consent:** CHOOSE ONE

I give consent for the storage, maintenance, and secondary use of my identifiable private information for future, yet-to-be-specified research, for the following types of research activities:
Publications and presentations of research findings
(Researchers should list types of future research activities here)

☐ Yes

☐ No

Statement of Consent: I have read the above information and have received answers to any questions I asked. I consent to take part in the study.

Your Signature ____________________________________ Date _________________________

Your Name (printed) ____

Researcher _____________________________________

Thank you for your willingness to participate in this project.

Parent/Guardian Informed Consent

Title: Sense of Belonging of STEM Students in Introductory Mathematics Classes
Investigator (s): Sarah H. Park

Your minor student (or the minor student for whom you are the primary guardian) was invited to be a participant in this study in order to understand students' firsthand experiences and sense of belonging in their mathematics class. Their instructor has agreed to participate in this study, but that does not mean that your student needs to agree to participate. Participation in this study is completely voluntary and optional.

Please read the following consent form. By signing, you agree to all terms and conditions of the research.

13) As a parent of ________________________, I give my consent to Sarah Park, to involve me in their study titled: Sense of Belonging of STEM Students in Introductory Mathematics Classes
14) **Purpose of the Study**: The purpose of this study is to examine students' sense of belonging and experiences in their college algebra or precalculus classes.
15) **Procedures to be followed**: Following this informed consent, I will be asked to complete a demographic questionnaire, pre and post surveys on my perceived sense of belonging in College Algebra or Precalculus. Demographic information and sense of belonging scores will be used, but students' identity will remain anonymous. Based on the survey results, a select number of students may be asked for follow-up interviews.
16) **Duration/Time**: This study will last approximately one semester.
17) **Discomforts and Risks**: I understand that this experiment does not pose any risks to me beyond those encountered in everyday life.
18) **Benefits**:
    a) While there are no benefits to the participants in this study, results will contribute to a growing research base of students' sense of belonging in the field of undergraduate mathematics education.
    b) The benefits to society and education include contributing to an understanding of how to better develop classroom structures and pedagogies that foster rather than hinder students' sense of belonging in their chosen STEM field. The study also has the potential to improve undergraduate mathematics education by informing the growing body of literature exploring how educators can best foster sense of belonging and support female minoritized students' aspirations and success in STEM classrooms and departments to increase their participation in STEM careers.
19) **Statement of Confidentiality**: I understand that no identifying information will be used in any report describing my behavior or responses and that only the students named above and the investigator will be informed of my participation in this activity (unless I ask to have a third party informed for proof of completion). This means that I will be randomly assigned an identification number that will be known only to the experimenter. My name or other identifying information will not be requested during the survey. My informed consent sheet, the only document that has my name, will be stored separately from my data.

20) **Right to Ask Questions**: Participants have the right to ask questions and receive appropriate responses to those questions. If you have questions about this study, please contact Sarah H. Park at [redacted] For questions concerning your rights as a research participant, contact [redacted] at [redacted].
21) **Compensation**: Participants may receive the satisfaction of knowing that they have helped contribute to science. Based on the survey results, participants may be asked to complete a math autobiography and ask to be interviewed. If selected for an interview, participants will be compensated $15 for their time.
22) **Voluntary Participation and Right to Withdraw**: I understand that I have the right to revoke this consent at any time. Moreover, even if I choose to continue to participate in an interview or other activity, I may decline to answer some questions or perform some tasks. The researchers guarantee that if I refuse to participate, there will be no penalty, no retribution, no impact on course grades, and no loss of benefits.
23) **Identifiable private information**: This research involves the collection of identifiable private information and I agree that identifiers may be removed, and **de-identified** information **may be** used or shared for future research without additional informed consent from me. Consent forms will be kept in a sealed envelope in a locked cabinet in an office until final grades are posted.
24) **Broad Consent:** CHOOSE ONE
    I give consent for the storage, maintenance, and secondary use of my identifiable private information for future, yet-to-be-specified research, for the following types of research activities: Publications and presentations of research findings.
    ☐ Yes
    ☐ No

Statement of Consent: I have read the above information and have received answers to any questions I asked. I consent to take part in the study.

Parent Signature ______________________________________ Date _________________________

Parent Name (printed) ____

Student's Name (printed)____

Researcher *Sarah H. Park* [redacted]

Thank you for your willingness to participate in this project.

Appendix G: Assumption Checks for One-Way ANOVA Model (Pre-Belonging)

All key assumptions for conducting a one-way ANOVA on pre-belonging scores were tested.

1. Independence of Observations: Participant's pre-belonging data are independent of each other based on the study design as each student contributed only one response.

2. Normality of residuals: The residuals are normally distributed based on the QQ plot and histogram.

3. Homogeneity of Variance: Levene's Test of Equality of Error Variances was not statistically significant (p = 0.510), indicating that the assumption of equal variances across groups was met.

Finally, visual inspection of boxplots and Q-Q plots did not reveal any extreme outliers.

Table G.1 *Levene's Test of Equality of Variances – Pre-Belonging ANOVA*

Levene's Test of Equality of Error Variances[a,b]

		Levene Statistic	df1	df2	Sig.
Pre_belongingscore	Based on Mean	.916	9	1126	.510
	Based on Median	.919	9	1126	.507
	Based on Median and with adjusted df	.919	9	1118.194	.507
	Based on trimmed mean	.922	9	1126	.505

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Dependent variable: Pre_belongingscore

b. Design: Intercept + genderxrace

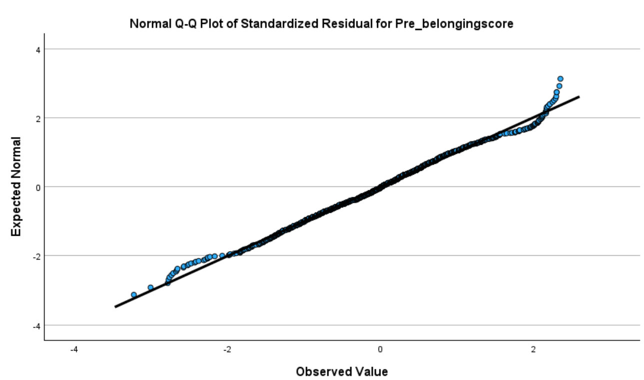

Figure G.1 *Q-Q Plot of Standardized Residuals – Pre-Belonging ANOVA*

The Q-Q plot indicates that most standardized residuals follow the diagonal reference line, supporting approximate normality despite a significant test result.

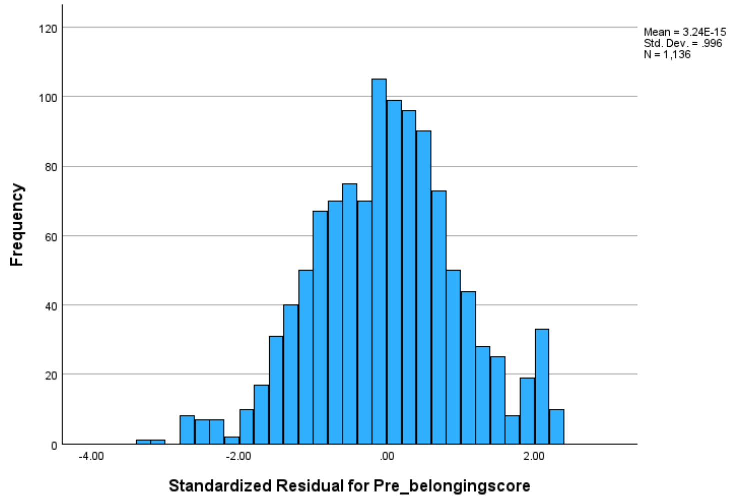

Figure G.2 *Histogram of Standardized Residuals – Pre-Belonging ANOVA*

Appendix H: Assumption Checks for Multi-Factor ANCOVA Model (Post-Belonging)

All key assumptions for conducting a multi-factor ANCOVA on post-belonging scores were tested.

1. Independence of Observations: Participant's post-belonging data are independent of each other based on the study design as each student contributed only one response.

2. Normality of residuals: The distribution of residuals is approximately normal based on the QQ plot and histogram. A normal Q-Q plot shows that most points fall near the diagonal line. A histogram of standardized residuals shows a roughly symmetric, bell-shaped distribution centered around zero. There are no extreme outliers.

3. Homogeneity of Variance: A non-significant result (p = .651) using Levene's Test of Equality of Error Variances indicates that the assumption of homogeneity of variances was met.

4. Homogeniety of regression slopes: Both interaction terms (Pre_belongingscore × post_mathaffinity & Pre_belongingscore × post_expected_grade) were non-significant (p > .05).

5. Linear relationships between covariate (pre-belonging) and dependent variable (post-belonging): The relationship between the covariate (pre-belonging) and the dependent variable (post-belonging) was linear, as indicated by a scatterplot.

Table H.1 *Homogeneity of Regression Slopes Test – Post-Belonging ANCOVA*

Tests of Between-Subjects Effects

Dependent Variable: Post_belongingscore

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	235.383[a]	58	4.058	16.203	<.001	.624
Intercept	7.855	1	7.855	31.361	<.001	.052
Pre_belongingscore	4.991	1	4.991	19.929	<.001	.034
genderxrace	1.195	9	.133	.530	.853	.008
Faculty	10.479	32	.327	1.307	.123	.069
post_mathaffinity	.668	4	.167	.667	.615	.005
post_expected_grade	1.864	4	.466	1.860	.116	.013
post_mathaffinity * Pre_belongingscore	.163	4	.041	.163	**.957**	.001

post_expected_grade * Pre_belongingscore	2.196	4	.549	2.192	**.069**	.015
Error	142.016	567	.250			
Total	12654.876	626				
Corrected Total	377.399	625				

a. R Squared = .624 (Adjusted R Squared = .585)

Table H.2 *Levene's Test of Equality of Error Variances for Post-Belonging Model*

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Post_belongingscore

F	df1	df2	Sig.
.947	525	100	.651

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Pre_belongingscore + genderxrace + Faculty + post_mathaffinity + post_expected_grade + post_mathaffinity * Pre_belongingscore + post_expected_grade * Pre_belongingscore

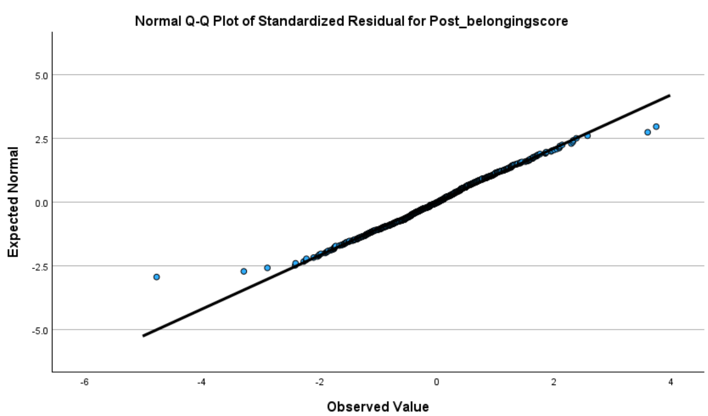

Figure H.1 *Q-Q Plot of Standardized Residuals for Post-Belonging ANCOVA Model*

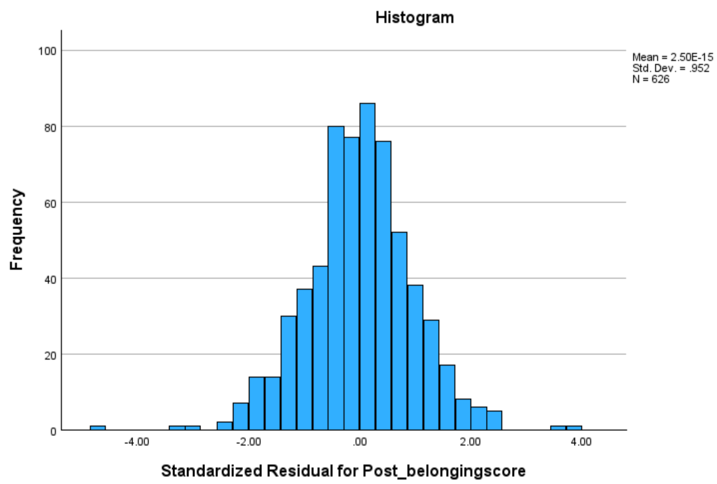

Figure H.2 *Histogram of Standardized Residuals for Post-Belonging ANCOVA Model*

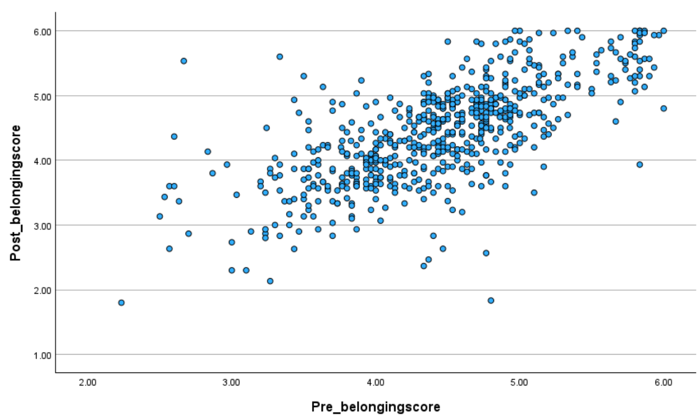

Figure H.3 *Scatterplot of Pre vs. Post belonging*

Appendix I: Assumption Checks for Multi-Factor ANOVA Model (Belonging Difference)

All key assumptions for conducting a multi-factor ANOVA on belonging difference scores were tested.

1. Independence of Observations: Each participant's data is independent of each other based on the study design.

2. Normality of residuals: The residuals are normally distributed based on the QQ plot and histogram. The Q-Q plot shows that residuals fall close to the diagonal reference line, indicating approximate normality. This histogram shows a symmetric, bell-shaped residual distribution centered around zero, with minimal outliers.

3. Homogeneity of Variance: The non-significant result (p = 0.806) in Levene's Test of Equality of Variances supports the assumption of equal variances across groups.

4. No perfect correlation between independent variables: The scatterplot of residuals vs. predicted values for belonging difference is roughly symmetrical and randomly scattered.

Table I.1 *Levene's Test of Equality of Variances – Belonging Difference ANOVA*

Levene's Test of Equality of Error Variances[a]

Dependent Variable: BelongingDifference

F	df1	df2	Sig.
.881	525	100	.806

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + genderxrace + Faculty + post_mathaffinity + post_expected_grade

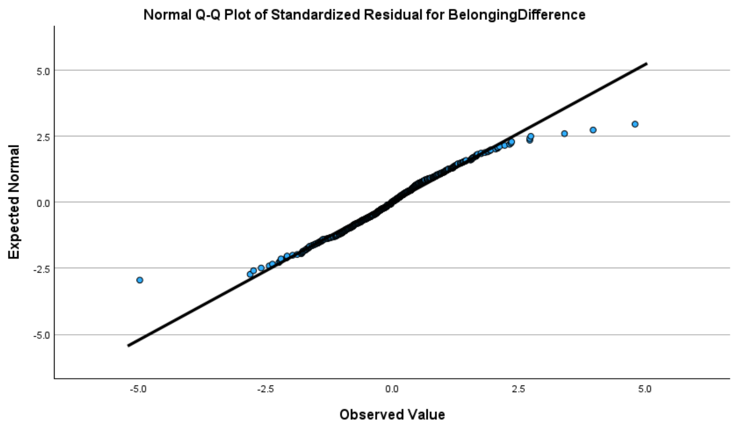

Figure I.1 *Q-Q Plot of Standardized Residuals for Belonging Difference ANOVA*

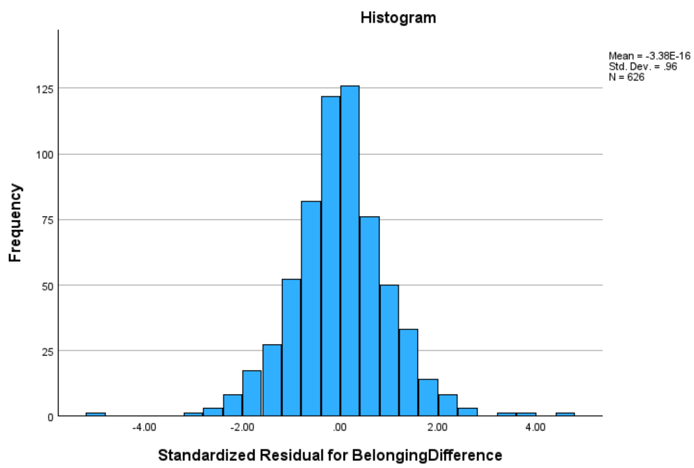

Figure I.2 *Histogram of Standardized Residuals for Belonging Difference ANOVA*

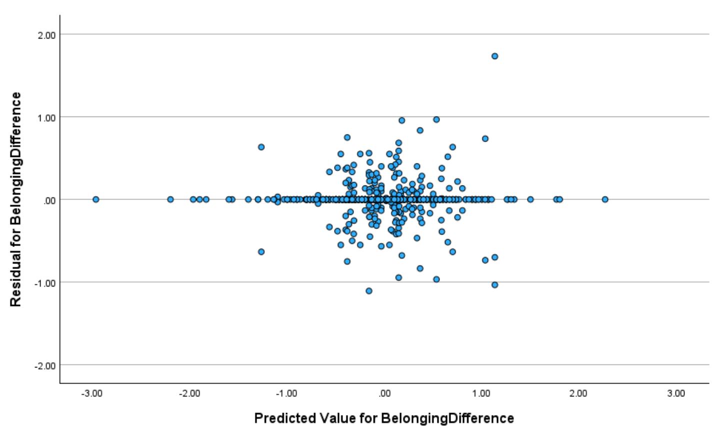

Figure I.3 *Scatterplot of Residuals vs. Predicted Values for Belonging Difference*

Appendix J: Mathematics Self-Efficacy Participant Quotes Categorized by Four Sources

Table J.1 *Participants Quotes Categorized as Positive Mathematics Self-Efficacy Based on the Four Sources: Mastery Experience, Social Persuasion, Emotional and Physiological States, and Vicarious Experiences*

Participants	Mastery experiences	Social Persuasions	Emotional and Physiological States	Vicarious Experiences
Alexa	Was “prepared” for the final exam. When asked what contributed to her higher sense of belonging at the end of the semester, Alexa responded, “ability to do the work well.”	Professor encouraged Alexa that she was “on the right track” or “you’re doing this perfectly” and she started do believe that “all of this is doable.”	When asked how has your sense of belonging impacted your progress and success in the course? Alexa replied, “I think it's increased my confidence with what I'm doing in the class.”	During group work all the students helped each other out. If she was struggling, her peers were able to help her. Alexa studied for exams together with her peers for hours.
Britteny (appears to have had positive mathematics self-efficacy before her 10th grade class)	A high point in my math experience was during middle school when I participated in a math competition. The competition not only boosted my confidence in math but also allowed me to meet other passionate students and share the joy of problem-solving.		Learning math in elementary and middle school was exciting. I loved grasping basic concepts like addition and multiplication, thanks to visual aids and interactive activities within the classroom.	
Jess	The classwork was easy.		I actually liked math class. It was pretty fun.	
Imani			What I remember about math in elementary school was that math was fun and engaging for a young kid, I had fun with math because it was easy. When I got to middle school my love for math didn't change. It was still fun but not as fun as elementary school math. I was still able to understand the concepts of the topics.	
Leslie	I'm really good at math.		I honestly love math, when I'm able to understand it.	I feel like it comes to me easy and I'm able

	I feel like my strongest part of learning is in math and I've always been good at it. I feel like I've grown to realize I have so much capability within math that I could unlock within now and the future. In 6th grade…I was finally able to find out how good I was in math. I would be the only person in class getting 100s on the tests, and I just felt like the class was too easy! It not only made me realize that getting good grades feels good, but it also unlocks my power within learning math." I'm proud of doing good in school, getting all A's and telling people I got all A's. The tests were easy to me and it was really relevant to what we were learning. Precalc class was very nice and I didn't struggle too much. There were some moments where it's like 'What is [the professor] saying? Or 'this class is really hard' but I'll get it once I do the review. I knew that I was just going to get it later.		Leslie felt "pretty comfortable" in class. About her final exam: I feel confident. I mean, throughout the class, I've done pretty good, so I'm not too worried." Getting good grades feels good, but it also unlocks my power within learning math. I do like math a lot. I also struggle a little bit as well, which is normal.	to understand it better than others. I guess for myself, it feels good to be able to say I'm good at this, I can help you with that. A girl around me struggled and I would help her every moment that she would ask. More students struggled more than me. I feel like I was one of the cases where it came easier.
Marlina (B)	At first, it would take me like 16 hours, I felt like there was a block. And then after about the first test, it	When the professor began praising her work that was a "good turning point for me. I	Whenever Marlina went up to the board to explain her work she said, "I was very proud of myself for	When working with her class peer, Marlina saw that her class peer was getting it.

	was like the block was lifting- and I was able to do the homework a lot faster. I think that's when I didn't feel the block anymore. I didn't feel like I was bad at math anymore. I felt like if I applied myself, then I could accomplish things.”	was like, "I'm getting it. Like, I can do this." Her class friend would encourage her “you got it, good job, you did that well.” I think my mom, she just kept saying like, "You can do it." First quiz, I got a 30, the next class-- the next quiz, maybe I got a 50. And she would be like, "You're doing better. Keep going."”	that. It made me feel really good.” But at the end, I’ve never missed. I only missed one class because I was sick, and but other than that, I looked forward to going. And I enjoyed it, ultimately. I was proud of myself in the end. Like my stomach would be enough just because I just felt like I didn't belong there. What was I doing? Everyone's going to know you're not good at math. And then it got better.	
Tyanna	My high point in math was getting an A+ in my algebra class in junior year. I don’t think there was anything hard. Everything I needed was given to me. So, nothing felt I couldn't do it.	Math tutors encouragement: They keep my head big. whenever, they go, you know how to do this, really. You're just so good.	I always liked math and over time my feelings have stayed the same. I was there [tutoring center] so I could get a deeper understanding of the work I was doing cause I want to know everything. I want to make sure I’m doing it right, that I’m executing the math right.	My mom likes math too so that might be where I get it from.

Table J.2 *Participants' Quotes Categorized as Negative Mathematics Self-Efficacy Based on the Four Sources: Mastery Experience, Social Persuasion, Emotional and Physiological States, and Vicarious Experiences*

Participants	Mastery experiences (Personal success)	Social Persuasions (encouragement or discouragement from others)	Emotional and Physiological States (or reactions)	Vicarious Experiences
Ana	I have always struggled with math and had bad experiences. Math has never been a strong subject for me. My math was always really bad. Even when I was younger, math has always been the one thing that I struggled with. Math has always been something that I struggled with since I was younger. Um, for some reason, when I look at math, all the numbers jumble up. It began in elementary school and then it just continued on until I was older. And by the time I was older, I felt I was too far behind to catch up in my math. I still don't know and I still have difficulty with simple division- I feel like my math level is so far behind at a third grade's level that it's difficult to catch up now to the algebra. I would try the problems and if I	My [high school] math teacher didn't really realize that I was struggling. She kind of just assumed that I didn't know how to do it- and instead of taking the time to teach me from square one how to do it, she kind of just left it alone. When her professor said things like, 'you should already know this' Ana said, "It was very embarrassing cause I felt like I didn't know what I was doing. It felt like other people knew that I was struggling and they were laughing at me. I felt like I was being judged.	Over time the feelings remain the same. Frustration gradually grows. Even simple division, simple multiplication, I still struggle with. And then, I do have trouble, getting help with it, with learning because it is quite embarrassing that somebody my age still has a lot of trouble with the math. I deeply struggle with math and I do try and get help in my own way, but it's embarrassing to me getting the help I need or even explaining my thought process. So I kind of just procrastinate in getting any type of tutoring help or help from friends. College algebra was very difficult. I tried it and then I would put it off and then I tried again and it was very discouraging. I didn't feel comfortable in that class. So I just put it off or I would try a little bit and I'd get discouraged and then I'd try again. It was a cycle where I tried a little bit and if I	

	didn't get them, I would just put it off again cause I didn't understand it. [Math] always been an issue. I didn't feel like I belonged. I didn't know the material. No matter what I did, I couldn't comprehend it. Ana felt that she didn't belong in class "anytime because the test because I knew that I wasn't going to pass." If I'm being completely frank, I'm not sure how I've been passing every single math class because I don't know enough math to be able to completely pass the my high school courses.		couldn't do it, I would put it off. It's always been an issue I just felt discouraged to try cause if I didn't understand basic Math, it felt like how would I understand algebra math? Everybody else was fine, they knew what [the professor] was talking about but I didn't know what [they were] speaking about because I felt I was so far behind to comprehend. I felt everybody staring at me because they knew that I didn't know. I knew that they didn't but I somehow felt judged. It's just a thought that comes into your head and it just sticks there. I did not feel comfortable at all [asking questions] It was embarrassing to actually go and say the words, 'I need help' so I just put it off and then the semester flew, and I just didn't get to it. By the time I did want to get to it, I felt that it was too late. The more that I knew that I couldn't get it, I couldn't do it, it's discouraging, where one gives up. I didn't really feel like I belonged. I didn't know the material. No matter what I did, I	

			couldn't comprehend it. I was too scared and embarrassed to get help and it felt like the teacher wasn't really there to help me. Ana felt like "an outsider for … not knowing as much as I really should know."	
Anela	The tests were simple, but I struggled a little bit. I actually-- I like math. I do. I enjoy math, especially if it's with the right professor explaining it to me. I'm not the best at it though.	I felt [my professor] was calling me stupid when they would yell at me. If someone is telling you over and over in an aggressive tone, this is review, you start to feel let down because I should know this. [My professor] always snapping on how people in should know this and how people aren't getting stuff. Once you keep hearing that it makes you feel like are you trying to say it's going on in our class? I felt like I wasn't smart enough because [my professor] kept oversaying, you don't get this, maybe you should drop out of the class right now. Statements like that I take it seriously when it's coming from a professor. So I did feel a little academically insecure. [My professor] would say, 'if you don't get this, you're definitely not going to understand that,' so there's no point in even doing.	I really didn't enjoy my math class. Maybe I wasn't smart enough… personal insecurities made me feel like I didn't belong. I didn't feel comfortable asking questions. I felt like [my professor] would try to embarrass me in front of the class. I don't want to be called out or embarrassed. I will ask [my professor] after everybody is gone to ensure I don't look stupid. [My professor's] actually discouraging. I did not feel encouraged. Towards the end of the semester, I didn't want to go anymore. I thought about withdrawing from the course because I did feel a little discouraged with how she talked about students.	Everybody in this class is struggling with review topics.

Alexa	A challenge I faced in math was my first semester junior year when it was time to take our first quiz and the more I looked through the questions the more I realized I had no idea how to do the problems.		It was the beginning of the semester where it was just a specific, like, set of problems that I was just like, "I don't know what I'm doing." Like, "I don't know what's happening." It was just more of like a, I don't know. I don't know who to ask. I don't know what I was doing.	
Britteny	Math is my weak spot. It wasn't more like anyone made me feel discouraged. It was like an internal thing. Like, "Wow, how come I don't understand this?" You know, there's some problems that you could do and you don't understand it. You just feel a little bit down, like, "Wow." You know, the way he explained it is so easy, but I'm just not getting it, you know?		I had to, you know, reassure myself like, if I didn't understand something and everybody else did, I felt bad in myself, ‘how you don't know this and everybody else does?’ I don’t really like math.	It was challenging for me because this is the first time I’ve learned certain topics, while for some of the students, they’ve seen it before, but it’s going more in depth. So when I didn’t understand, sometimes you can feel like you’re left out because everybody knew something about it.
Faith	Because she felt that she was doing poorly in class she did not want to work with her class peers as much: “I chose not to only because I was doing bad in the class I didn’t want them to have a question and then not be able to rely on me because I didn’t understand. I didn’t want them to help me but me not being able to help them. So I didn’t rely on anyone in the class. My grade is not good so I don’t want to teach them		I never really felt comfortable asking for help in general. I have a bad habit of not asking for help. I just tried to figure it on my own. I should just try to figure it out on my own, I don’t want to be a bother. I don’t want the teacher feel like I’m not paying attention in class. I could teach myself or figure it out. I’m not the best at math. It takes me a while sometimes.	Everyone seems to understand. I think it’s just more of a me problem.

	wrong or bring their grade down if they've been working hard. I'm just trying to pass right now. In math I'm like 'oh we just learned this I forgot how to do it.' I feel like I have test anxiety. I can study a good amount of time but when I finally take the test, I forget everything.		When Faith doesn't understand something in class she said, "I honestly didn't resolve it. I just kept it to myself" I'm more quiet when I don't understand. Because I was doing bad in the class, I didn't want them to rely on me because I didn't understand. I didn't want them to have to help me but me not being able to help them. So I didn't really rely on anyone in the class. My grade is not good. I don't want to teach them wrong or bring their grade down if they've been working hard. I felt like the environment was good and I had a good teacher, but I just feel like my want to do good gets in the way of doing actually good. If I know I have a test coming up, I may procrastinate on studying because I'm like what if I don't get a good grade or what if I don't study enough? I feel like I was trying really hard and it doesn't really show in my work. I put a lot of effort it.	
Imani			I don't like math as much as I used to when I was younger because of the complexity of it now and my feelings did change over time because I went from	

			loving it because it was fun and simple to not liking it anymore because it became too complex for me.	
Jess	About elementary and middle school mathematics: “I remember it being very difficult because of how far behind I was and still am learning wise” I don’t have a high point in my math experience as of now. It'll be like during group work or like if I don't understand it, I'll just let someone else kind of take over. I don't feel confident at all in it, because if someone tells me like, okay, I kind of see where you're going, but if I do it by myself, I don't know what's going on. I don't even know how to start it sometimes if I'm doing it by myself. I’m still not good at math, so it takes me a while from others to understand something or get something down. So tests be kind of tough for me. I was moving around from school to school like five different elementary schools so I was not able to learn certain stuff.	There's a lot that I missed out that teachers think I'm just like genuinely like joking with them. My math teachers, they swear I was lying. It'll be like some math teachers like would help me, but they'd be like, "Okay, you must be pulling a joke on me” Like those specific things, I just did not understand, and not help me sometimes. They'll give up on me. In high school, I would tell like one of my teachers-- I think it was my 11th-grade math teacher. I told her like, "Certain stuff I didn't learn like other people because I was barely in school my elementary," and she was like, "Well, you got to get it together." She didn't try to help me. She was just more like talking to her like students as if they were her friends. So she would not try to actually like sit down and help me.	I kind of feel like it's kind of like a little unnecessary. Maybe because I'm not good at it. I feel that math is a bit much and unnecessary and irritating. It has not changed over time. I would try to hide it a bit or try not to show that I was struggling. And then when I go back to my dorm try to regroup myself a little bit because sometimes the struggling that I do in class does kind of like aggravate me myself. Like I could've been known this. but other people do. but I just don't. And it kind of annoys me. Because like I'll be like the only one struggling, you know, and that would be-- that make me feel like I'm just getting heavily judged. I feel nervous a little bit when it’s speaking around like a whole class. I stay really low. If I get it wrong most of the time, trying not to bring me down because I’m still kind of learning the questions I got to remind myself. There’ll be some times where I feel like I just don’t know what I’m	When people are instantly understanding the math problem and I’m still stuck on the first example I could not like get math questions down like everybody else would, even from elementary school, I will be the last person. It’s hard to keep up with people who does math questions pretty fast or does it well and I wouldn’t. Out of all these people I’m probably the only one who’s mathematically behind because of all the movement I had to do.

			talking about math-wise. I'm still struggling but I still try my best to not give up. Jess felt that she didn't belong in class when "everybody would get a question down and I'm still trying to figure out how do you even go about it? It made me feel a little bit left behind. They'll be on a whole another question and I'm still on the few questions way behind them.	
Joselyn	Math class, it was very challenging I have my struggles cause unfortunately, I took math five years ago so my memory is not all that great. The hardest thing about the class for Joselyn was "trying to comprehend the material"		I just felt like I didn't belong to class because I hadn't took math in so long. I guess the level of knowledge. Initially when I first started, I was doing fine. There wasn't no issues. But the more we got into different materials, that's when it felt like I wasn't ready to take this class, like I felt like I didn't belong in that class. I felt like I don't want to say dumb but I wasn't too knowledgeable.	There's times where I know where the whole class was struggling, it was noticeable the whole class was struggling. I know sometimes where everyone would know the answer, but I would get a completely different answer and I guess that made me kind of, I think I'm doing something wrong, I'm not learning the right way, or maybe I wasn't seeing what they were seeing in the problem.
Julianna	Yeah, I always struggled in math. I've always struggled with math since I was young. At first I was feeling confident, fresh start, hoping to understand a lot more. The first week, I feel like everything just		I remember learning my multiplication facts, and I never got it. It's just embarrassing. In math, I felt a little more anxious. It felt like I had a time limit. I feel like I'm not really confident in math. I always doubt myself.	Sometimes I felt nervous because we work as a pair sometimes, but I would-- I felt like the person next to me understood more math than I did. And I was embarrassed because I was still working on like the third step while the person next to me

	dropped onto me, I was like, Oh my God, this is a long of work, and I wasn’t prepared for that. Like while doing my homework, I’d be like, I don’t remember learning this… I don’t think I understand it… then it started getting worse. It would take me four hours to do my homework or even more. It was really difficult. In elementary and middle school, I was always struggling in math. It takes a while for me to understand, to learn something. I feel like three to two weeks is not enough for me. I don't know. And then I'm not good on my own, like having to learn on your own, because I know these lecture classes, you learn some of it, but then you also have to go back home and like learn it yourself, study and do the homework, but I kind of struggle with that.		In the beginning, I felt kind of confident. I was like, "Okay, fresh start, maybe I'll understand it." I didn't know it was going to be that difficult. And I guess I just me emotionally, I'd be really upset and having to not understand in math. Then the first week, I feel like everything just dropped on to me. This is a lot of work, and I wasn’t prepared for that. It’s a lot of information to process. While doing my homework, I’d be like, I don’t remember learning this. And then having to learn on the textbook. I’d be like I don’t think I understand it. Then it started getting worse.” I'm really bad at math to begin with, so it just, you know, how like there's steps into math, you learn this thing and it moves on to this thing, you'll use that thing and this thing. I kind of-- no, I don't know. I don't know how to explain it. I just don't-- I'm not really good at math I also have a learning disability, which makes it even worse. It's hard to memorize numbers. I can't memorize formulas sometimes, so I can't do the problem if I don't know the formula.	already had the answer. I didn't really like it.

			It would take me like four hours to do my homework or some questions or even more. It would take like two days. I'd do half on a day and then half the other day to finish. It was really difficult. that when I would take my quiz, or my test I would forget it, and I'd be like, "Oh I remember seeing this in my homework like two nights ago." And it's like I get really mad at myself because I was like, "Oh, I understood it in the homework but then in the test and the quiz I didn't seem to understand it from what it looked like." For Julianna the hardest part of being a student in her mathematics class was, “not understanding concepts from elementary, then moving on to middle school and then high school and then college.” Julianna didn’t feel belonging when she “didn’t understand stuff in the class. That would just ruin my whole mood. I’d be having a good day at school and then when I go to my math class, afterwards, I feel so upset. I hate it. I’d leave the class and like, I know I’m gonna fail this. I would dread to go to class. I’d be like I need to get over it but…”	

Kayla	I struggle with math real bad. My greatest challenge was honestly when I had to retake a class in my junior year to make it possible that I pass that year on time. I had to do lots of practice problems and maintain motivation although it took a tremendous mental toll. I still ended up failing the class and ended up going to summer school, where we ended up doing more practice work. Not really comprehending the material that we were provided, I think that really decreased my grade. On my test I don't know what I'm doing. Looking back, I don't think they were that difficult, but at the time, I was like, I can't do it. Class was a little difficult. I had a lot of motivation at first and I felt good starting off my first year of college and math. But as the class started to go on, I felt I'm not really good at learning, my brain scatters all over the place.		I never really enjoyed math unless I actually understood it. Which was very unlikely because it's not my strongest subject nor have I really ever passed it. I tend to get anxious sometimes, so, or like anxiety yeah. So I don't really ask questions. The hardest part was getting through it, the overwhelmness. Kayla feels like she doesn't belong in a mathematics classroom when-Not knowing the material and how unmotivated I am when it comes to math because I've always struggled with it. I feel like a lot of people felt the same that they couldn't pass because it was hard and it was overwhelming and the environment just… I don't know." Mentally, I was so overwhelmed that took a tool on me and I felt very discouraged and unmotivated within the class. I just get really overwhelmed. When I started to feel like that, I found the class more difficult.	The friends that I had would side talk like 'I don't know why I'm taking this class.' A bunch of people just dropping, it was really hard to get through it and want to go to class in general. Observing how everyone was feeling when they would be like 'how do you do this' or 'I'm so confused' or 'I'm going to drop this class' I would hear all these conversations and that's what made me feel like I'm not going to do good in this class. To hear everybody else feeling kind of the same thing. I felt like this isn't going as good as I thought it was. Even if I really tried, I just couldn't learn in this environment.
Marlina	I've never been good at math. the first class we had a quiz I failed the quiz, and so I'm	"I've always been told, That's not your subject" Even in school I always felt I wasn't	Frequent quizzed made Marlina feel "pressurized" she left class feeling "feeling defeated because you didn't do well on your	

	leaving class and I'm crying because it's just making me feel like, it's solidifying what I felt that I wasn't good at math. I had never taken pre-cal, never took it in high school, and so I was extremely nervous that I wasn't gonna do well in it. The first class we had a quiz I failed the quiz, and I'm leaving class and I'm crying because it's just solidifying what I felt that I wasn't good at math but then it kind of also was like a push, it kind of pushed me to do better. At first, it would take me like 16 hours to do one [HW problem] I felt like there was a block.	good at math, and so I kind of projected that, and then other people projected it back onto me. I was raised around people who were just exceptionally good at math, and it came like second nature. So when it didn't come second nature to me, it was just brushed off as like, "You're not good at math, you're good at history." Even my friends, you need to do something else, but not the math part."	quiz or you didn't, you knew you didn't understand that, but you had just learned it 20 minutes ago." At first, I dreaded it. I absolutely like my stomach would be in knots going in there. Like I just wanted to throw up before I went in there. I hated it. Like my stomach would be enough just because I just felt like I didn't belong there. Like, "What was I doing?" Like, "Everyone's going to know you're not good at math." Like, and then it got better.	
Tyanna			During exams, she feels like the only one that's, like, "I don't know what's going on." I get really anxious. Taking tests "stresses me out" I like math but I get really anxious [during tests]. I know the information but I'll make silly mistakes. When we're taking tests, I finish and I think it was pretty bad. I'm the only one that's like I don't know what's going on.	