ABSTRACT

Title of Dissertation:	THE PERSISTENCE AND SUCCESS OF UNDERGRADUATES IN REMEDIAL MATHEMATICS: A MIXED METHODS STUDY ON MATHEMATICS SOCIALIZATION AND SEGREGATED SPACES IN UNDERGRADUATE EDUCATION
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This explanatory sequential mixed methods study (QUAN-QUAL) was developed to investigate the question: "*How do sociohistorical, intrapersonal, and institutional factors relate to the persistence and success of undergraduates enrolled in remedial mathematics classes at a four-year university?*" To understand this complex phenomenon, I employed Martin's (2000) Multilevel Framework for Analyzing Mathematics Socialization and Identity Among African Americans for both streams of data collection and analysis. I collected and analyzed departmental and survey data quantitatively, to identify broader patterns of relationships that existed among the participants' intrapersonal factors, demographic characteristics and their persistence and success (*n=316*). The participants' high rates of persistence (92%) and success (68.4%) could partially be

explained by enrollment in a corequisite versus emporium remedial mathematics course, but also institutional (non-randomized sorting and placement into course type by placement test score), sociohistorical (primarily advanced high school mathematics course-taking) and intrapersonal (perceptions of the teacher) factors. Age, gender, African American identity, first-generation status, and high school mathematics course-taking all contributed to persistence and success to some degree, but gender was a stronger predictor of persistence and success than minority or first-generation status, and high school mathematics course-taking was the most influential demographic predictor of persistence, when course enrollment was excluded from the regression model.

The intrapersonal factor, *perceptions of the teacher*, was also a significant predictor of persistence, and to a lesser extent, success. This finding led me to select extreme perception of teacher cases ($n=5$) for the qualitative portion of the study. The qualitative data revealed that several institutional and classroom factors impacted the emporium participants' experiences, beliefs and perceptions and ultimately, their persistence and success. These participants presented negative perceptions of their emporium course's online instructional platform and revealed the negative impact the course structure had on teacher behaviors, their relationship with their teacher and the classroom environment overall. The three STEM majors had more negative socio-academic experiences at the university than the two non-STEM majors because their placement into remedial mathematics was a barrier that prevented them from declaring and pursuing coursework for their STEM degree. Socio-economic factors, such as not having the financial means to live on campus and having heavy work and family responsibilities, compounded the adverse effects of remedial mathematics placement for two of the STEM majors, and the two female STEM majors were diverted out of STEM altogether. The two non-STEM participants who persisted through their emporium courses reported leveraging a variety of intrapersonal, academic and social assets, such as their financial motivation, the socio-academic support of their peers and advisors, their parents' positive perceptions of their academic abilities, and university academic supports, when they were faced with challenges in their emporium classes. Although the STEM majors did not persist, they were nonetheless actively engaged in agentive behaviors dedicated to their degree attainment.

THE PERSISTENCE AND SUCCESS OF UNDERGRADUATES IN REMEDIAL MATHEMATICS: A MIXED METHODS STUDY ON MATHEMATICS SOCIALIZATION AND SEGREGATED SPACES IN UNDERGRADUATE EDUCATION

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Dissertation submitted to the Faculty of the Graduate School of the University of
Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2019

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ACKNOWLEDGEMENTS

I would like to extend sincere thanks to the faculty (and former faculty) at the Center for Mathematics Education, who believed in my ability to take on and endure this monumental task six years ago, including Jim Fey and Anna Graeber, without whom, I would not have been able to persist myself. To my dissertation committee, Lawrence Clark, Ann Edwards, Kimberly Bethea, and Susan De La Paz, I am truly grateful for your committed support and expertise. Thank you. I would also like to thank Elizabeth Shearn and Debra Franklin for their generosity and willingness to support my dissertation ideas and work. There is no way that any of this would have been possible without your encouragement and commitment to students in remedial mathematics. I especially want to thank Andrew Brantlinger, my advisor and dissertation chair, who was kind, patient, and encouraging throughout my graduate program and dissertation process. Finally, I would like to thank my colleagues in the College of Education and fellow graduate students in the Center for Mathematics Education for your positivity and academic and emotional support over the past six years, especially Diana Bowen, my doctoral buddy and dear friend, Kelly Watson Ivy, my sounding board, and Dana Grosser-Clarkson and Elizabeth Fleming, my cheerleaders and mentors.

I would like to dedication this dissertation to my mother and father, who instilled in their four daughters a value for education and being educated, my sisters Patti Reynolds, Margaret Farmer, and Kim Cano, who motivated me to finish, Bill and Shirley (RIP) Daisey and the Daisey family, for modeling the importance of family, character, hard work and love, and for your kindness and support. To Dionne Daisey Williford, for

your friendship, laughter and memories, and to Lydia, Ella, George and Katie, you are my greatest treasures.

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CHAPTER 1: Introduction

Undergraduate remediation has been at the forefront of national discussions on college and career readiness for decades, and it has "increasingly become part of the national debate in higher education" (Bonham & Boylan, Developmental mathematics: Challenges, Promising Practices, and Recent Initiatives, 2012, p. 14). According to Bonham and Boylan (2012), "[this] is particularly true for developmental mathematics courses which, in general, have the highest rates of failure and non-completion of any developmental subject area" (p. 14). While the intention of mathematics remediation is to provide students with basic mathematics skills identified as necessary for success in college-level mathematics courses, there is no national or state-by-state consensus on what constitutes college readiness in mathematics and the placement of students into remedial mathematics is a localized phenomenon (Attewell, Lavin, Domina, & Levey, 2006; Bailey, 2009a).

Undergraduate mathematics remediation is a racialized phenomenon. Minority, first-generation, and low-income students disproportionately place into remedial mathematics classrooms (National Center for Educational Statistics, NCES, 2005). In 2007-2008, Sparks and Malkus (2013) reported that remedial courses consisted of 19.9% White, 30.2% Black, 29% Hispanic, 22.5% Asian or Pacific Islander, and 27.5% students who identified as two or more races. The overrepresentation of minorities, first generation, and low-income students in undergraduate mathematics remediation is tied to differential access to higher level mathematics in high school (U.S. Department of Education for Civil Rights, 2014). However, high school mathematics experiences are not the sole culprit for the disproportionate representation of these students in undergraduate mathematics remediation. Placement exams, which typically "measure only some of the skills needed for a successful college experience" (Bailey, 2009b, p.1), may also be a factor. Attewell et al. (2006) reported that, "about 40% of traditional undergraduates" (p. 886) take at least one remedial course. However, as few as 5 percent of students enrolled in remedial mathematics earn their college math credits within one year of continuous enrollment (Carnegie Foundation for the Advancement of Teaching, 2014). Typically, remedial mathematics students, "spend long periods of time repeating courses and leave college without a credential…unable to progress toward their career and life goals" (Van Campen, Sowers & Strother, 2013, p.1).

The high numbers of minority, first-generation and low-income undergraduates placing into remedial mathematics, and the low rates of retention and success in these courses, have caused many to argue that remedial mathematics is, "a gateway to postsecondary participation for many minority students" (Boylan, Bohnam & Tafari, 2005, p. 60). Thus, remedial mathematics is an equity issue. However, little research on undergraduate remediation incorporates an equity lens. This lack of focus on equity in remedial mathematics research may be due to the historical marginalization of equity research in mathematics education (Gutstein, 2006; Lubienski & Bowen, 2000). To centralize equity, several mathematics education researchers have argued for the incorporation of sociocultural frameworks in mathematics education research (Nasir & Cobb, 2007). These frameworks allow researchers to examine the individual, cultural, school and institutional contexts which contribute to a student's mathematics identity development. Integrating such a framework into remedial mathematics research provides the field an opportunity to develop a more intimate understanding of the relationship between the mathematics context and student experiences, beliefs, perceptions, and motivation. Furthermore, it helps us understand how they respond to perceived challenges and opportunities in their mathematics associated contexts.

Within community college and four-year public and private college settings, there is no underlying set of national or statewide standards for placing students into remedial mathematics, but few researchers are including state and institutional policies, institutional practices, and the uniqueness of the localized phenomenon within their reports. Furthermore, a wide range of remedial programs fall under the umbrella of remedial mathematics research and are not always disaggregated in large scale data sets or thoroughly described in the study. Finally, much of the existing research on undergraduate remedial mathematics examines the effect of remediation, which sadly, is little to none (Bailey, 2009b). While there are quantitative studies that examine the impact of a specific reform or sociocultural factor on student persistence and success, these studies often failed to provide the intricate details necessary to uncover what is truly happening to students in these courses and how the variety of sociocultural contexts in which remedial mathematics is situated may relate to undergraduates' agency, persistence, and success.

Little research on remedial mathematics incorporates sociocultural frameworks, although these frameworks have gained acceptance in mainstream K-12 mathematics education research over the past decade (Lerman, 2000). One sociocultural framework, Danny Martin's Multi-Level Framework for Analyzing Mathematics Socialization and Identity Among African Americans (2000), considers sociohistorical, community, school and intrapersonal contexts in which students engage with mathematics and the processes and experiences, "by which individual and collective mathematics identities are shaped" (Martin, 2000, p. 19) within these contexts. Students' mathematics identities are a compilation of their beliefs (about their math abilities, the importance of mathematics, and their ability to perform in mathematics context), perceptions (of barriers and opportunities in mathematical contexts), and "the resulting motivations and strategies used to obtain mathematical knowledge" (Martin, 2000, p. 19). Thus, this particular sociocultural framework connects students' mathematics identities with their contextualized experiences, beliefs, perceptions, motivations, and actions.

Using his Mathematics Socialization and Identity framework as an analytical tool, Martin (2000) was able to examine the variety of social forces that impacted African American high school students' mathematics identities, agency, and persistence and success in their high school mathematics. A subsequent study, *More Than Just Skill: Mathematics identities, socialization, and remediation among African American undergraduates,* employed Martin's framework in case study research on African American undergraduates enrolled in remedial mathematics in a university setting (Larnell, 2011). Martin (2000) and Larnell's (2011) qualitative data on African American mathematics students revealed that students with similar demographic attributes perceive and interpret their mathematics experiences differently, and how they interpret their experiences directly impacts their beliefs about themselves and mathematics. These beliefs, coupled with family, peer, and school relationships, impact how a student exhibits agency and effects whether they persist and succeed in mathematics (Larnell, 2011; Martin, 2000). While quantitative studies on remedial mathematics examine factors that impact persistence and success by subgroup, Martin and Larnell's qualitative findings suggest there is more to persistence and success than demographic data alone can reveal.

Statement of the Problem

Undergraduate remedial mathematics has been called a "graveyard of dreams and aspirations" (Bryk, quoted by Merseth, 2011, p. 32). While remedial mathematics may help some students develop mastery in basic mathematics skills and enroll in college-level mathematics, it is largely seen as a national problem that has actually derailed millions of students from achieving their college education and career goals (Bailey, Jeong, & Cho, 2010; Carnegie Foundation for the Advancement of Teaching, 2014; Sparks & Malkus, 2013; Van Campen et al., 2013). Despite decades of data that indicates many of our nation's first-year undergraduates place into remedial mathematics courses and that these students have significantly lower graduation rates than other undergraduates (Complete College America, 2012), recent research also shows we have made little progress in improving these outcomes (NCES, 2005; Sparks & Malkus, 2013). In 2008, a study of nearly 86,000 college freshman revealed that three-fourths of remedial mathematics students did not successfully remediate (Bahr, 2008). Thus, one key objective in recent form efforts is to, "improve the experience in the classes and get students to enroll and stay in those classes" (Bailey, 2009a, p. 20).

In the early 2000s, a wave of remedial mathematics reform initiatives began across the country. These efforts have included: K-12 and college curricular alignment (Frost, Coomes, & Lindeblad, 2009); staff professional development (Edwards, Sandoval, & McNamara, 2015); evaluation of placement policies and exams (Guy, Puri, & Cornick, 2016; Medhanie, Dupuis, LeBeau, Harwell, & Post, 2012); course condensing (Bassett &

Frost, 2010); computer-based remediation (Potocka, 2010; Wladis, Offenholley & George, 2014); learning communities (Scrivener, Bloom, LeBlanc, Paxson, Rouse, & Sommo, 2008); affective support systems (Hammerman & Goldberg, 2003; Taylor & Galligan, 2006), and alternative pathways (Carnegie Foundation for the Advancement of Teaching, 2014; Hern & Snell, 2014). Private organizations (including the American Mathematics Association of Two-Year Colleges, the Bill and Melinda Gates Foundation, the Carnegie Foundation for the Advancement of Teaching and others), as well as federal institutions (such as the Department of Education's Institute of Education Sciences), are trying new approaches to remedial education (Bailey, 2009a). Unfortunately, research findings on the effects of these reform initiatives have been inconsistent and often contradictory (Bailey, 2009b) due to the enormous amount of variability that exists across local and institutional settings, placement policies, student populations, and the types of research conducted (Bailey, Jaggars & Scott-Clayton, 2013).

Purpose of the Study and Research Questions

The purpose of this study is to identify sociohistorical, intrapersonal, and institutional factors that contribute to the persistence and success of undergraduates enrolled in remedial mathematics courses at a four-year university. Currently, there is a lack of research on (a) undergraduates enrolled in remedial mathematics classes at four-year colleges and (b) how these students' mathematics socializations impact their beliefs, perceptions and motivation to persistence in remedial mathematics. The literature review presented in Chapter 2 will demonstrate that, although a variety of research methods have been employed to study this problem, there is little use of complementary research methods within any given study. Furthermore, few studies incorporate a sociocultural framework to examine the complex relationships that exist among multiple factors. As such, researchers of remedial mathematics have called for, "rigorous studies that investigate, at a finer level of detail, the specific aspects of programs that are associated with program success" (Valentine, Hirschy, Bremer, Novillo, Castellano, & Banister, 2011, p. 214), and for studies "that investigate the interaction between programs and student characteristics to determine what types of programs are most effective for which students" (p. 214). Applying Martin's Multi-Level Framework for Analyzing Mathematics Socialization and Identity Among African Americans (2000) using a mixed methods approach allows me to investigate both general trends and complex interactions in a large population of learners and also to deeply examine these play out for a small number of study participants.

This study addresses the following primary research question: "*How do sociohistorical, intrapersonal, and institutional factors relate to the persistence and success of undergraduates enrolled in remedial mathematics classes at a four-year university?*" Sub-questions include:

a. What personal goals and motivations are important to undergraduates enrolled in remedial mathematics courses?

b. What do they believe about mathematics and their mathematics abilities?

c. What are their perceptions of the school climate, their peers and teachers in mathematics contexts?

d. What motivates their learning of mathematics?

e. How do they express agency in response to perceived opportunities and challenges related to their remedial mathematics courses and requirements?

To address these questions, I utilize a mixed methods methodology that incorporates Martin's (2000) Multi-Level Framework for Analyzing Mathematics Socialization and Identity Among African Americans. For the remainder of the dissertation, I will refer to this framework as Martin's Mathematics Socialization and Identity Framework.

Conceptual Framework

As stated above, this research incorporates Martin's Mathematics Socialization and Identity Framework (2000; figure 1). This framework considers sociohistorical, community/family, school/institutional, and intrapersonal factors that contribute to students' identity development, agency, and persistence. For this study, I focused my data collection and analysis of the components that are bolded in figure 1. As evidenced in figure 1, the components that are bolded correspond to sociohistorical, institutional and intrapersonal factors. These components were selected because the goal of this dissertation study is to examine sociohistorical and institutional contexts and to prioritize the voices and perspectives of remedial mathematics students in the university setting. By prioritizing students' intrapersonal factors, including their goals, perceptions and beliefs, the students are repositioned from a space that has historically marginalized their voices to a space where they are positioned as valuable and powerful agents of change. This repositioning is intentional and is in alignment with critical race theory constructs.

Figure 1: Multi-Level Framework for Analyzing Mathematics Socialization and Identity Among African-Americans: Key Themes From Martin's (2000) Framework

Sociohistorical

- **Differential treatment in mathematics-related contexts**

Community/Family

- Beliefs about African-American status and differential treatment in educational and socioeconomic contexts
- Beliefs about mathematics abilities and motivation to learn mathematics
- Relationships with school officials and teachers
- Math-dependent socioeconomic and education goals
- Expectations for children and educational strategies

School/Institutional

- **Institutional agency and school-based support systems**
- Teachers' curricular goals and content decisions
- Teachers' beliefs about student abilities and motivation to learn
- Teachers' beliefs about African-American parents and communities
- **Student culture and achievement norms**
- **Classroom negotiation of mathematical and social norms**

Intrapersonal

- **Personal identities and goals**
- **Perceptions of school climate, peers, and teachers**
- **Beliefs about mathematics abilities and motivation to learn**
- **Beliefs about the instrumental importance of mathematics knowledge**

By incorporating this framework in a mixed methods design, I can identify the broader contexts that impact the persistence and success of the university's remedial mathematics population and use these larger patterns to develop a more nuanced understanding of the relationship between specific experiences, beliefs and perceptions and a participants' persistence and success. A five-year longitudinal study on the 2001 revision of the remedial mathematics program offered at this university (Shearn, Kim, & Vernille, 2005) and a recent Complete College America report (CCA, 2012) indicated that the remedial mathematics students at this university have abnormally high persistence and graduation rates, with no racial or gender gaps (Shearn et al., 2005). Insights into these students' mathematics experiences and sociocultural contexts can help to shed light on which programs or factors are most helpful to which students. These findings may be beneficial to other states, organizations and college institutions working to improve remedial mathematics programs and outcomes (CCA, 2012).

Conceptual Foundations

Sociocultural Theories

Martin's Mathematics Socialization and Identity Framework (2000) incorporates a sociocultural perspective. The sociocultural perspective draws from theories in anthropology, sociology, and cultural psychology which contend that mathematics learning is a social activity and that, "knowledge and identity are intricately linked and situated in specific practices" (Gutierrez, 2013, p. 40). Sociocultural theories draw heavily on Bandura's Social Cognitive Theory (1997) which postulates that personal, behavioral and environmental forces are interrelated, and that perceived self-efficacy is essential to individual agency. According to Bandura, people attribute their self-efficacy to past experiences, and these beliefs regulate their cognition, motivation, emotion, and decision, ultimately influencing the "effort they put forth, how long they will persevere, whether their thought patterns are self-hindering or self-aiding, how much stress and depression they experience, and the level of accomplishments they realize" (Bandura, 1997, p. 2-6). Efficacy develops through mastery experiences, social modeling, social persuasion, or self-regulation, and “efficacious people are quick to take advantage of opportunity structures and figure out ways to circumvent institutional constraints or change them by collective action” (Bandura, 1997, p. 6).

Critical Race Theory

Research on mathematics socialization has shifted toward centralizing the student experience, giving voice to those who are or have been, historically marginalized. As such, Gutierrez (2013) and others have noted a shift from the sociocultural to the sociopolitical. One sociopolitical framework that is relevant to this study is critical race theory. There are five tenants of critical race theory (CRT) often used to frame educational research (Lynn & Dixson, 2013). They are the centrality and intersectionality of race and racism; challenging the dominant perspective; a commitment to social justice; valuing experiential knowledge and maintaining an interdisciplinary perspective. Race and structural racism are central issues in remedial mathematics, and race intersects with social class, first-generation status, gender, nativity and English language proficiency in remedial mathematics research. Through Martin’s Mathematics Socialization and Identity Framework (2000) and mixed methods design, I centralize the value of students’ experiences, beliefs, and perceptions in identifying and appropriately responding to issues of persistence and success. The qualitative portion of the study is focused on African American students who were enrolled in the emporium remedial mathematics classes. By highlighting their unique stories, these students are provided with the opportunity to give voice to the barriers and opportunities afforded to them at the university as a result of their remedial mathematics placement. My incorporation of sociocultural theories and CRT into this mixed method study also helps me to shift remedial mathematics discourse from a “cognitive deficit” perspective toward an examination of the whole student and all of her complexities.

Significance and Contributions

Recent reform efforts in remedial mathematics, and research on the impact these reforms have on student retention and college completion, provide evidence that there is a need for ongoing research on remedial mathematics. Specifically, there is a need for research that attends to programmatic details, the diversity of students enrolled in remedial mathematics, and what they perceive as barriers or supports to their success. While there is a growing body of quantitative research on the impact of remedial mathematics and factors associated with retention and completion, little research incorporates sociocultural contexts, and even less examine remedial mathematics students who are successful at highly selective universities.

Four-year colleges are spending nearly half a billion dollars each year on remediation, and community colleges spend almost five times that each year. It is pertinent that we begin to develop a clearer picture of what sociocultural factors benefit students enrolled in these programs. If we can identify models and attributes that support student persistence and success, “more students will be retained and graduate” (Belfield, Jenkins & Lahr, 2016). As Shearn et al. (2005) discovered in their longitudinal study of remedial mathematics reform, shifting policies and programs can lead to increases in the percentage of remedial mathematics students who pursue STEM degrees. This finding has vast implications for minorities who are overrepresented in remedial mathematics (NCES, 2005; Sparks & Malkus, 2013) and underrepresented in STEM (Cole & Espinoza, 2008).

Definitions of Key Terms

The following definitions will assist readers in understanding the literature, research methods, findings, discussions, and conclusions:

African American/Black

For this study, I the term African American/Black applies to participants who are 1st and 2nd generation African American. In the qualitative portion, I present the candidates the way they identify themselves and include whether they are 1st or 2nd generation African American in their description, when applicable.

Corequisite Remedial Mathematics Courses

An accelerated, hybrid course that offers students both remediation and college level mathematics within one semester.

Developmental Mathematics

Mathematics remediation that incorporates support systems aimed at addressing cognitive, affective and behavioral components of mathematics learning (Higbee, Arendale & Lundell, 2005)

Emporium Remedial Mathematics Courses

Replaces traditional lectures with a computer lab which incorporates computerized remediation and on-demand, personalized assistance from an instructor (Wong, 2013).

Supplemental emporium courses. The supplemental emporium model augments lectures with online, out of class activities.

Replacement emporium courses. The replacement model replaces some of the lectures with online learning activities.

Full emporium courses. The fully online model eliminates class meetings and offers a purely online environment driven by course management software. The university under study incorporates an adaptation of the full model. There is no lecture, and all activities are online. However, all students are required to complete online activities in a computer lab where an instructor or TA are physically present.

Intrapersonal Factors

The participants' motivations; their beliefs about their mathematics abilities and the fundamental importance of mathematics; their perceptions of their school climate, peers, and teachers, and their motivation to learn mathematics (Martin, 2000).

Mathematics Identity

Beliefs about mathematics abilities, the fundamental importance of mathematics, "constraints and opportunities in mathematical contexts, and the resulting motivations and strategies used to obtain mathematical knowledge" (Martin, 2000, p. 19).

Mathematics Socialization

The processes and experiences, "by which individual and collective mathematics identities are shaped" (Martin, 2000, p. 19).

Mixed Methods

The mixing of research methods, methodologies, and paradigms to, "dialectically catalyze new and deep understandings not possible with one methodological standpoint alone" (Greene, 2012, p. 758).

Persistence

The participants' successful completion of their developmental mathematics requirements by the end of their fall semester.

Productive Agency

Behaviors that remedial mathematics instructors identify as supportive of their students' mathematics persistence and success (Zeinteck, Schneider & Onwuegbuzie, 2014).

Remedial Mathematics

Mathematics remediation at the undergraduate level is aimed at addressing cognitive deficits in mathematics (Higbee et al., 2005) which are identified through a number of means, but predominantly, through placement tests which sort students into either college level mathematics courses or mathematics remediation (typically non-credit bearing mathematics courses).

Success

The participants' ability to pass their subsequent college-level mathematics course (by the end of the spring semester) with the minimum grade required for their major.

Chapter Conclusion

There are many reasons why I was motivated to research the mathematics socializations of undergraduates enrolled in remedial mathematics courses and how these socializations impact their agency, persistence, and success. My undergraduate studies were rooted in social sciences, and my undergraduate thesis was on Native American Identity. Although part of my interest in sociocultural research, particularly identity research, stems from my personal experiences, it is also deeply rooted in the stories of my mathematics students.

My educational and teaching experiences have led me to understand that persistence and success are far more complex than cognitive ability or performance. Over the years, I have worked with hundreds of students who have struggled in their mathematics because of negative experiences. I have also become acutely aware of the power that mathematics and mathematics proficiency has had on my students, their academic identities and their self-efficacy. It is overwhelming to consider the extent of damage that negative mathematics experiences have had on my students' beliefs about themselves and their abilities. I will never forget my top seventh-grade student telling me she was "never good at mathematics," or my college student reflecting that she was informed she could not pursue mathematics, despite her interest and proficiency, because she was female.

In my first year of teaching middle school, I noticed deficit beliefs that some of my students held because of their low self-efficacy in mathematics and became determined to counter them. I incorporated complex, open-ended tasks, peer work, music, games and lots of candy and care into my middle school classes and witnessed positive shifts in my students' mathematics and academic self-efficacy and achievement. I was unaware of the trauma relating to undergraduate remedial mathematics until I began teaching these classes years later at a small, rural, community college. My first semester of teaching, on the day of the first exam, I approached my classroom to find some of my adult students were crying hysterically in the hallway because they were overwhelmed with fear. These students were academically proficient in every area of their studies except mathematics, and their remedial mathematics coursework was holding them back from completing their programs and obtaining their degrees. It became my goal to empower them. At the same time, I began to question the validity and benefit of remedial mathematics and to seek ways to improve it. Now that I better understand the depth and complexity of the "remedial mathematics problem," I am even more determined that we resolve it. The "remedial mathematics problem” is an equity issue that is rooted in structural racism and social stratification. It is a gatekeeper that continues to limit the degree attainment of our most marginalized students. To uncover the resources that most support remedial students’ persistence and success, we must create a space for them to share their stories about the context in which they experience remedial mathematics, their opportunities and challenges, how they respond to their perceived opportunities and challenges, and their suggestions for improving their experiences and outcomes.

In the chapter that follows, Chapter 2, I set the research context by first providing a literature review on research relevant to this study. This literature review demonstrates the need for further research on (a) undergraduates enrolled in remedial mathematics at four-year colleges and (b) how remedial mathematics students’ mathematics socializations relate to their agency, persistence, and success. In Chapter 3, I outline the research design and methodology employed in the study. Chapter 4 is a presentation of my quantitative findings, and Chapter 5 is a presentation of my qualitative results. In Chapter 6, I summarize the implications of the integrated quantitative and qualitative data, report on the affordances and limitations of the study, and identify goals for future research.

CHAPTER 2: Literature Review

In this chapter, I provide an overview of the literature on undergraduate remedial mathematics developed to establish context for my study. I begin the chapter by briefly summarizing relevant research on mathematics socialization from K-12 literature. Then, I use the factors outlined in Martin's Mathematics Socialization and Identity Framework (2000) to organize and introduce research that pertains to the mathematics socializations of undergraduates in remedial mathematics. I conclude the chapter by synthesizing the research and point to gaps in our understanding to make a case for a mixed methods study on the mathematics socializations and identities of undergraduates in remedial mathematics at a 4-year university.

Remedial Mathematics

As stated in Chapter 1, the goal of undergraduate remedial mathematics is to provide students with the underlying mathematics skills identified as necessary for success in college-level mathematics courses. Recent reform efforts attend to systemic change and non-cognitive factors that influence student retention and success (Higbee et al., 2005). These reform efforts have seemingly shifted the discourse from mathematics "remediation" to "developmental mathematics." While mathematics remediation aims to address cognitive deficits in mathematics, developmental mathematics incorporates support systems aimed at addressing cognitive, affective and behavioral components of learning mathematics (Higbee et al., 2005). The goal of the university under study is to remediate, so I have chosen to adhere to the term remediation when presenting my study and findings. However, you will notice that developmental mathematics is the dominant discourse in the literature presented below.

There are several remedial mathematics instructional models discussed in the literature. As noted in Chapter 1, the *emporium model* replaces traditional lectures with computerized remediation and on-demand, personalized assistance from an instructor. The *supplemental emporium model* augments lectures with online, out of class activities. The *replacement emporium model* replaces some of the class lectures with online learning activities, and the *fully online model* eliminates class meetings and offers a purely online environment driven by course management software (Wong, 2013). The university involved in this study incorporates a modified version of the fully online model. There is no teacher led instruction, and all learning activities are online. However, students in this university's emporium courses are required to complete their online modules in the remedial mathematics computer lab where an instructor or TA are present and available for individual assistance.

Accelerated remedial models condense traditional remedial mathematics sequences. They can occur in lecture format or any of the emporium spaces mentioned above. The corequisite model is an accelerated, hybrid course that offers students both remediation and college-level mathematics within one semester. The university under study also incorporates the corequisite remedial model. Finally, alternative pathways are fully redesigned courses that focus on statistical and quantitative reasoning and are typically provided to non-STEM majors (Carnegie Foundation for the Advancement of Teaching, 2014).

Persistence is critical for students in remedial mathematics. It impacts whether they complete remediation and their required college mathematics credits, and ultimately, whether they graduate (Bailey, 2009a). Thus, much of the research on remedial mathematics examines the impact of reforms on retention, graduation, or success rates. This body of literature is generally comprised of quasi-experimental, quantitative studies. Many of these studies use transcript data in order to predict persistence and success using factor analysis and logistic regression.

Due to the disproportionately high rates of non-persistence and drop out among undergraduates enrolled in remedial mathematics, researchers have closely examined whether remedial mathematics improves achievement, persistence and success outcomes for some time. According to Bailey et al. (2013), most of their studies have compared non-equivalent students such as remedial and college-ready cohorts, or pre and post-treatment cohorts who were not propensity-matched. Thus, findings from these studies do not reliably measure the impact that remedial mathematics has on student success (Bailey et al., 2013). In response, a recent wave of research has incorporated a statistical method called regression discontinuity. In regression discontinuity, researchers use "large, longitudinal data sets and quasi-experimental methods to derive more reliable estimates of the effects of remedial education on those students near the cutoff score for developmental placement" (Bailey 2009b, p. 2). Regression discontinuity is a nonexperimental design that examines cut point discontinuity on the premise of localized randomization (Jacob, Zhu, Sommers, Bloom & MDRC, 2012, p. 4). Since the cut-off score is arbitrary, any differences between students that fall just above and just below the cutoff are random (Jacob et al., 2012, p. 6), and causal estimates are comparable to those of randomized experiments (Cook, Shadish & Wong, 2008). If "the two groups are identical before remedial assignment, (and) remediation has any beneficial effect, it would show up as a positive difference in outcomes" (Bailey et al., 2013, p. 3)

Overall, regression discontinuity studies have not uncovered better outcomes for students who receive remedial education compared with those students who do not; “instead, remediated students just to the left of the cutoff score have no better and sometimes worse outcomes than students just to the right” (Bailey et al., 2013). Lesik (2007) found that students in remedial mathematics at a four-year, state university had significantly lower risk of dropout after their first and second year at the university when compared with equivalent students who did not receive remedial mathematics (8.2% vs. 27.7% and 4.4% vs. 16.5%, respectively; p. 601-602). Also, “students who did not participate in the remedial program are approximately 4.3 times more likely to drop out of the university during their first three years when compared to equivalent students who do participate in the remedial program” (Lesik, 2007, p. 603). Moss, Yeaton, and Lloyd. (2014) found that remedial mathematics students at a large, multi-campus community college, “benefitted from the college’s developmental mathematics policy” (p. 181). However, the magnitude of the benefit was “typically, one quarter to a third of a grade, (and) average grade was not significantly different for the two study conditions” (p. 181). In contrast, Dadgar (2012) and Scott-Clayton and Rodriguez (2012) found null and negative effects for community college students enrolled in remedial mathematics. Scott-Clayton and Rodriquez’ discovered that, “those assigned to math remediation were 5 percentage points less likely to pass college-level math, 4 percentage points less likely to ever earn a C or better, and 2 percentage points less likely to ever earn a B or better in college-level math (p. 21). Therefore, “approximately one-quarter of the students diverted out of college-level courses could have earned a least a B there” (p. 21). Thus, a number of researchers argue that “students at many points in the remedial continuum are unlikely to be harmed by attempting courses that are slightly more difficult than their placement scores suggest they can handle" (Bailey et al., 2013, p. 9).

Retention, persistence, and success studies dominate the literature on remedial mathematics. Retention and success are examined to determine whether students stay in, and complete, mathematics remediation, whether they earn their college mathematics credits, and whether they graduate within three years (at the community college level) or six years (at the four-year college level). Typically, persistence and retention are used interchangeably in the literature and refer to the percentage of first time, full-time degree-seeking students who enroll in a given fall semester and return the following fall. Remedial success typically relates to the percentage of students who complete course work in remedial mathematics, and graduation rates typically apply to the portion of the first time, full-time degree-seeking students in a cohort who graduate within six years (at the undergraduate level; Dougherty & Reid 2006).

Mathematics Socialization

As indicated, this study incorporates Martin's (2000) Multi-Level Framework for Analyzing Mathematic Socialization and Identity Among African-Americans. This framework considers *sociohistorical, community/family, classroom/institutional and intrapersonal factors* which shape an African American student's mathematics experiences and identity. Researchers who study K-12 mathematics education have identified that a number of these factors impact African American students' persistence and success in mathematics. Specifically, *sociohistorical factors* rooted in racism negatively impact minority, first generation and high poverty students' mathematics experiences, persistence, and success (see, for example, Achieve Inc., 2006).

Joi Spencer and Victoria Hand argued that, in educational spaces, mathematics "is uniquely poised to reinforce the story that racism tells" (as cited in Drakeford, 2015, p. 238). For example, although we are a culturally diverse nation, Western European mathematics dominates our mathematics curricula, and students have little to no exposure to non-European mathematics or non-European mathematical practices. Thus, the mathematics learning opportunities we provide to students in the U.S. reinforce the oversimplified and racialized narrative that Western Europeans (i.e. White teachers and students) are leaders in mathematics and mathematical thinking while non-Western Europeans (i.e. non-White teachers and students) have little to no role in mathematics and are not mathematical thinkers. This deficit dominant narrative of minorities in mathematics presents itself, and is reinforced, in mathematics classrooms across our nation and is most evident in our system of mathematics tracking, where minority students, particularly African American, Latinx and Native American students, are most likely to be low tracked and the least likely to have access to advanced mathematics classrooms and highly qualified mathematics teachers. Our Euro-centric presentations of mathematical thinking, teaching and learning have historically, and continue to, influence assumptions of intelligence, leading to academic and social stratification where White students are at the top and minority students are at the bottom (Drakeford, 2015, p. 238). These sociohistorical and classroom contexts most certainly result in racialized mathematics experiences of minority students.

Danny Martin's research on African America students' racialized mathematics experiences has brought sociohistorical contexts, particularly racism, to the forefront of African American students' mathematics persistence and achievement discourse. Martin's

Multi-Level Framework for Analyzing Mathematic Socialization and Identity Among African Americans (2001) is a valuable analytical tool for examining the mathematics socializations of students in university remedial mathematics because the sociohistorical context of social stratification by race can be analyzed in relation to the students mathematics experiences, identities, agency and persistence. Furthermore, Martin's framework (2001) has previously been used to qualitatively analyze the mathematics socializations of African American undergraduates in university remedial mathematics classrooms (Larnell, 2011). The application of this framework to a mixed methods study is appropriate for the broader remedial mathematics population because, although undergraduates in remedial mathematics are not only African American students, they are predominantly minority students and predominantly African American. This framework allows me to consider the racialized experiences of African American students in undergraduate mathematical spaces without neglecting the complex mathematics socializations of non-African American remedial mathematics student population.

Furthermore, remedial mathematics is the social stratification of minority students through mathematics tracking in a highly competitive and deterministic setting. As Spencer and Hand argued, "Tracking and surveillance of school mathematical practices, together with the perception of mathematical capacity as a measure of general intelligence has had profound implications for the perspectives of black students and communities about their capacities as humans" (Drakeford, 2015, p. 248). Martin's (2001) framework forefronts the student perspective and mathematical identity within sociohistorical, institutional, community and intrapersonal contexts. Given the underrepresentation of African Americans and minorities in STEM careers, it is essential to consider the ways in which racialized mathematics experiences of university remedial mathematics students contribute to their mathematics and STEM identities and cracks in their STEM pipeline. The research reviewed in the remainder of this chapter is organized thematically, using the key contextual factors from Martin's (2000) framework outlined above to present what we know about the influence these factors have on the persistence and success of undergraduates in remedial mathematics.

Sociohistorical Factors

Placement into remedial mathematics. There is evidence that differential experiences in high school mathematics, such as the type of math curricula a student is exposed to, the number of years of high school math they received, and their subsequent ACT math scores are related to remedial math course-taking. In addition, students having the high school mathematics experiences that are linked to placement in remedial mathematics at four-year colleges are more likely to complete high school in an urban area and be in the lower quintiles of a variable reflecting general learned abilities (Harwell, Medhanie, Dupuis, Post, and LeBeau, 2014). Using multi-site student data gathered from 32 four-year college institutions (*n=13,188*) Harwell et al. (2014) discovered that race and the student's major were predictors of remedial mathematics course placement. African American (36%) and Hispanic (26.1%) students were more likely to place into remedial mathematics than White students (10%), and humanities majors were 9.6 times more likely to take remedial math than STEM majors.

Predictors of persistence and success. Persistence and success are shaped by a range of factors. Davidson and Petrosko (2015) examined predictors of persistence in remedial mathematics at a community and technical college system in Kentucky. They found both academic and dynamic factors, such as work and family factors, to be statistically significant predictors of persistence. In terms of academics, these researchers reported that a student's overall current grade point average doubled the likelihood she would persist, and students who enrolled in an in-person course, with an online component, "were about one and a half times more likely to persist than students who took the course in person" (p. 170). Also, general studies majors were 1.5 times less likely to persist than all other majors, with the exception of undecided and allied health majors (p. 170). For dependent students, influential factors such as credit accumulation and higher parent income levels resulted in increased persistence, but the effects were small. For independent students, those who participated in a federal work-study were 3 to 4 times as likely to persist, and those who received a waiver or third-party award were about twice as likely to persist; however, these predictors were only statistically significant in spring-to-fall persistence. As indicated by the previous finding, they found differences between fall-to-spring and spring-to-fall predictors of persistence. Thus, they argued for the "need to further evaluate predictor factors with regard to specific term-to-term persistence" (p. 175).

Related, Wolfle (2012) examined the success of remedial mathematics students in their subsequent college-level mathematics course and their fall to fall persistence in a community college setting in Virginia (*n=756*). Using logistic regression, Wolfle found that "the majority of remedial students (72.2%) never attempted a college-level mathematics course," (p. 47). However, among those who did attempt a college-level mathematics course, those who were initially in college-level (52.2%) or remedial mathematics classes (49.3%), "persisted (from fall to fall) at statistically similar rates" (p. 47). In addition, Wolfle identified ethnicity and age as significant predictors of a remedial mathematics student's success in her first college-level mathematics course, but remedial mathematics status was not a significant predictor of a student's success in her first college-level mathematics course (p. 47). Also, ethnicity and remedial mathematics status were not found to significantly predict of fall-to-fall persistence.

Community and Family Factors

Community factors influence students' persistence and success in remedial courses and the university. Tinto (1975) argued that, "Individuals enter institutions of higher education with a variety of attributes (e.g., sex, race, ability), precollege experiences (e.g., grade-point averages, academic and social attainments), and family backgrounds (e.g., social status attributes, value climates, expectational climates), each of which has direct and indirect impacts upon performance in college" (p. 94) Related, Ellington and Frederick (2010) found that successful African American mathematics majors had high levels of cultural capital. They came from two-parent households (at least at the beginning of their formative years), had mothers who nurtured their interest in learning, and either had or were pursuing their Bachelor degrees. They also had fathers who nurtured their interest in mathematics and science, had nurturing and caring teachers who challenged and motivated them, and were in Gifted, Honors, and Advanced Placement courses from elementary to high school. Their study participants exhibited spiritual strength, positive attitudes, perceived self-efficacy, and a belief in the importance of mathematics. They felt supported by the broader black community and wanted to give back to their communities in return.

Institutional Factors

Affective supports. A number of institutional factors impact the persistence and success of remedial mathematics students. Incorporating affective supports, such as study strategies, formative assessment and self-regulation strategies increase remedial mathematics students' motivation, attitudes, and achievement. Mireles, Offer, Ward, and Dochen (2011) incorporated a mixed-methods design to investigate the impact that study strategies have on motivation, attitudes and productive academic behaviors at remedial mathematics students at a four-year, urban university. The participants in this study "reported increases on the learning and study strategies inventory (LASSI) scales in study strategy usage" (p. 16). Also, "t-tests indicate(d) an overall reduction in anxiety for this group of students" (p. 16). The participants who were exposed to the study strategies intervention most frequently reported decreased anxiety, improved attitudes, and increased motivation" (p. 19).

Also, Hudesman, Crosby, Ziehmke, Everson, Isaac, Flugman, Zimmerman and Moylan (2014) examined the impact of formative assessment and self-regulated learning on remedial mathematics students' achievement. They developed an Enhanced Formative Assessment and Self-Regulated Learning program (EFA-SRL) for community college students which incorporated metacognitive skills and formative feedback. They found the treatment group had significantly higher mean grades and pass rates than the control group (5.2 vs. 4.1, $p=.008$, and 79.2% vs. 63.5%, $p=.029$, respectively; p. 116).

Classroom learning environment. Classroom factors, including instructional strategies and the classroom learning environment are linked to undergraduate and remedial mathematics students' self-efficacy, motivation and persistence. Solomon (2007) examined the mathematics identities of undergraduate STEM majors at an English university. She reported that undergraduate "math can only be made accessible to all in a participatory pedagogy which encourages exploration, negotiation, ownership of knowledge, and the development of a corresponding identity of participation" (pp. 92-93). Related, drawing on remedial mathematics student data collected from five four-year colleges that participated in the Connect the Dots (CDT) project (*n=1,336*), Kinzie, Gonyea, Shoup, and Kuh (2008) discovered "student engagement had a positive, statistically significant effect on persistence, even after controlling for background characteristics, other college experiences during the first college year, academic achievement, and financial aid" (p. 26). Moreover, they discovered that while, "African American students at the lowest levels of engagement are less likely to persist than their White counterparts, they become more likely than White students to return for a second year as their engagement increases" (p. 26).

Students who have an instructor that they perceive as effective, one who: is positive, makes math fun, clear, creative and interesting, and develops a rapport with students motivates them and helps them develop identities of inclusion (George, 2012; Wicker, 2002). On the other hand, students who feel isolated by the classroom environment and instructor's pedagogical practices can develop identities of exclusion, resulting in, "negative relationships with mathematics which marginalizes them and can turn them against further study" (Solomon, 2007, p. 93). Acevedo-Gil, Santos, Alonso, and Solorzano (2015) reported the impact of curricular practices on the self-efficacy and persistence of Latinx students in remedial education at three community colleges in the greater Los Angeles area. They used a validation framework to analyze student data and found that students most often encountered validation and invalidation through curricular practices. Invalidating events, such as placing into remedial education and exposure to deficit and demeaning pedagogical practices, "had a negative effect on the educational experiences of participants, lowering educational aspirations, academic self-confidence, and self-efficacy" (p. 108). However, institutional agents also provided academic validation. Academic validation occurred when institutional agents (such as instructors and counselors) set high expectations and focused on social identities in tandem with improving academic skills" (p. 101).

Curricula. A variety of curricular reform studies indicate that alignment across remedial and college-level mathematics content is poor, and that accelerated curricula is more successful than computerized curricula. Johnson (2007) discovered that the Intermediate Algebra skills taught at one public, liberal arts, university were unnecessary for 3 of the four college mathematics courses it preceded. Also, the one class that required Intermediate Algebra skills, Pre-calculus, was pursued by only 9% of the students who placed into Intermediate Algebra. Thus, Johnson (2007) recommended that institutions review their curriculum and, if necessary, adapt their curricular policies to reduce the chance that students will receive prerequisite remediation for mathematics courses they do not need.

Emporium courses. The evidence in favor of improved student persistence and success resulting from online versions of remedial courses is mixed. Some studies point to benefits of online coursework. In a quasi-experimental, historically-controlled study of over 20,000 community college students at a large, diverse, urban community college, Wladis, Offenholley and George (2014) found that implementing a mandated online intervention to students at risk of failing by mid-term increased pass rates by as much as 50%. Not surprisingly, they found pass rates for participants receiving the supplemental emporium intervention had “a relatively strong association between a student's attendance in the intervention lab or time spent on intervention assignments and his/her passing rate" (p. 1090). Also, students entering remedial mathematics with higher Pre-Algebra scores made the most significant gains from the intervention. Similarly, Potocka (2010) found mean scores for online sections were the same or better than the mean scores for in-class sections at a four-year, public liberal arts college. The participants in these full emporium courses were provided with "(1) mathematical and technical support provided by a Ramapo College adjunct instructor, available for 3 office hours a week, (2) live mathematical tutors available 40 hours a week and technical support staff available 24 hours a day, 7 days a week, both reachable through a 1-800 number listed on CourseCompass.com, and (3) mathematics tutors at a tutoring center on campus" (p. 500) free of charge. Also, Bassett and Frost (2010) reported increases in retention (74% to 83%) and pass rates (41% to 60%), and a 20% reduction in cost per student (p. 872) when Jackson State's Community Colleges combined three remedial mathematics courses into one full emporium remedial mathematics course.

Other studies have pointed to less positive student persistence and success outcomes for online versions of remedial courses. Bendickson (2004) found "retention rates for remedial mathematics in computer-based courses were as low as or lower than retention rates in traditional lecture-based courses" (as cited in Zavarella & Ignash, 2009, p. 2). Zavarella and Ignash (2009) reported similar findings from their study on remedial mathematics students located at a large urban community college. They found, "students in the computer-based format were more likely to withdraw from the course compared to those in the lecture-based format" (p. 2). Participants in their study primarily identified themselves as collaborative and participant learners, and although "learning style did not appear to impact the completion or withdrawal of students" (p. 6), participants who enrolled in a course because it met their personal needs had greater odds of completion. Kinney's (2001) mixed-methods study on student beliefs about computer-mediated courses and their retention and pass rates at a four-year university had mixed results. Although "students in computer-mediated courses value being active learners and having control over their learning" (p. 12), no significant difference existed between pass rates for lecture and computer-mediated courses, and withdrawal rates were inconclusive (p. 16). Also, Aycaster (2001) examined factors impacting success in remedial mathematics and subsequent mathematics courses at two-year colleges in the Virginia Community College system. While she found that retention rates were higher for students in remedial mathematics classes, success rates were “independent of the type of instruction used” (p. 413). However, she did report that high enrollment (>25) negatively impacted retention rates (p. 412).

Accelerated courses. Accelerated courses have demonstrated consistent, positive effects on retention and pass rates. Based on their research on the effects of The California Acceleration Project (CAP), Hern and Snell (2014) revealed that the community college participants, “at all levels of remediation, including three and four levels below college, saw gains in accelerated pathways, and the lowest placed students saw the largest relative increases in their completion of college-level gateway courses” (p. 32). In a similar vein, the Tennessee Board of Regents (2016) found that the "co-requisite model transformed [their] previous success rate of fewer than 10% of students completing a credit-bearing math class, over several semesters, to more than 70% completing a credit-bearing math class in a single semester" (p. 1) across their community colleges. These positive outcomes held for students “across the full spectrum of the student population at every ACT-level” (p. 3). During the pilot and full implementation of the corequisite model, minority success rates “rose more than six-fold, from its historical 6.7% to 41.8%” (p. 5). Further, “the success rates for adults showed an almost five-fold increase…from 11% to 52.3% [and] results for low-income [students] in the full implementation showed little difference from the general population with success rates in mathematics at 48.4%” (p. 6). In response to sustained, positive findings on co-requisite remedial mathematics courses, Palmer (2016) argued that, "[a]t scale, co-requisite remediation has the power to improve students', especially underrepresented students', persistence and completion of college degrees. Moreover, only states and systems have the tools at their disposal to support that scale” (p. 3).

Learning communities. Learning communities, as part of or as a supplement to a remedial mathematics course, have been examined in multiple settings, and the findings collectively support the claim that minority students who are overrepresented in remedial mathematics appear to benefit more from learning communities than their White peers. For example, first-generation students at four-year universities have higher retention rates and greater academic success when they, “report more participation in group discussion, presentations, and group projects and who more frequently discuss courses with other students” (Amelink, 2005 cited in Kinzie et al., 2008, p. 32). Hooker (2011) reported similar results for First Nation students who attended a tribal community college in Montana. After developing a peer-led team learning (PLTL) intervention that incorporated workshop activities focused on group problem solving, language and conceptual development, and collaboration, completion rates nearly doubled (23% versus 43%; p.

223). Persistence rates also increased to 47% “compared to 32% in the traditionally taught class” (p. 224). Survey and interview data from students in the PLTL treatment group “indicated growth in two categories: 1) personal or social skills (such as increased confidence, accountability, assertiveness, and self-esteem) and 2) academic skills" (p. 224).

A commitment to diversity and inclusion. Institutional leadership that are committed to low-income students and students of color, and staff that are committed to students’ success support high academic achievement and undergraduate success rates across racial and income sub-groups. Flores and The Center for American Progress (2014) investigated policies and practices at UCLA, Riverside; USF, Tampa, and UNC, Charlotte to understand how these four-year institutions “maintained a graduation gap across demographic groups that is near or below zero” (p. 4). All three of the universities indicated "a mix of federal, state, and institutional financial support was crucial to increasing access and degree attainment for low-income students and students of color" (p. 4). The university administrators credited numerous student support services to improved academic retention and graduation rates. Some of the services cited were federal TRIO programs, labs, tutoring, summer bridge programs, workshops, learning communities, advising, freshman-specific seminars, and establishing a "critical mass" for minorities on campus. Institutions have higher minority student retention when they are committed to, "inclusiveness in staff and constituencies served; diversity in vision, mission, values, processes, structures, policies, service delivery and allocation of resources; and an operating philosophy of social justice" (Grieger, 1996, cited in Boylan et al., 2005, p. 61). Those that provide faculty mentors and role models have increased minority academic achievement (Alberta & Rodriguez, 2000; Boylan et al., 2005; Daloz, 1999; Ellington & Frederick, 2010).

Scholarship programs that provide financial aid, summer bridge programs, study groups, faculty and peer support, and opportunities to mentor and attend professional conferences have also been linked to minority undergraduate success (Ellington & Frederick, 2010).

Placement, enrollment and exit policies. Although research on placement, enrollment, and exit policies indicate the lack of state and national standards regulating remedial mathematics course placement and enrollment, these policies clearly impact remedial mathematics students' ability to persist and succeed. In a mixed methods study of assessment and placement policies at nine community colleges, Melguizo, Kosiewicz, Prather, and Bos (2014) found that "only 13 states have legislated the use of a common assessment and common cut scores (Fulton, 2012, cited on p. 694). Also, although Virginia, North Carolina, and Connecticut developed common cut score policies as a part of the Achieving the Dream (2010) initiative, there was not a faithful implementation of state placement requirements. In addition, Medhanie, Dupuis, LeBeau, Harwell, and Post (2012) reported that for over 1,300 students at twenty two-year and four-year colleges or universities, the commonly used placement exam, ACCUPLACER, "does not contribute to either the prediction of enrollment or subsequent success in (remedial) courses, and that comparable information is provided by using the ACT mathematics score alone" (p. 332). Similarly, while multiple measures of assessment have been found to improve access to higher-level mathematics courses, Ngo & Kwon (2015) found that in the community college setting, "matriculation coordinators, institutional researchers and faculty regarded multiple measures as insignificant and treated them as a matter of legal compliance" (p. 707).

However, placement and exit policies have been linked to persistence and success. Guy, Puri, and Cornick (2016) found that policy changes resulting in higher entry and exit standards in one community college in New York City were associated with a significant decline in remedial sequence completion (from 57% to 28%) and credit-bearing course completion (from 79% to 60%). In addition, timely enrollment, as opposed to delayed enrollment, in remedial mathematics has been linked to improved outcomes. Fike and Fike (2012) found that, at an urban, private university, delayed enrollment had adverse effects on fall to spring retention. Similarly, Zienteck, Schneider, and Onwuegbuzie (2014) surveyed remedial mathematics instructors' at community colleges to identify their perceptions about student placement and success in remedial mathematics ($n=89$) and found that faculty primarily attributed placement into remedial mathematics to "a time lag between current and previous engagement with mathematics courses" (p. 67).

Systemic reforms. Systemic reform initiatives which incorporate a variety of interventions previously discussed above promise improved persistence in remedial mathematics and success in college-level mathematics. The Carnegie Foundation for the Advancement of Teaching developed two alternate pathways in their systemic overhaul, the Statway course, and the Quantway course (Carnegie Foundation for the Advancement of Teaching, 2014). In both paths, students can earn college credits within one year. While these alternative pathways are accelerated courses, the program incorporates some unique additional features. Instructors and their mathematics departments undergo a six-month training before teaching the courses; students have access to their curriculum and instructor both in class and online; students complete pre-assigned home activities before attending face to face classes on a particular topic, and instructional materials emphasize group work and peer collaboration. The adoption of Statway at two-year and four-year colleges has increased college credit completion rates from 6% to 49% in one year, (Sowers & Yamada, 2015, p. 5). Success rates in Quantway are equally promising: 56% of students complete Quantway 1, and 67% of students complete Quantway 2, earning their college mathematics credits (Sowers & Yamada, 2015, p. 7-8).

A second systemic reform initiative from Texas, FOCUS, also shows promise. FOCUS incorporates culturally relevant and contextualized capstone problems, situational mathematics and technology, mini-instructional episodes on hot topics; Socratic question and answer sessions, and the Concrete, Representational, Abstract (CRA) model into curriculum and instruction (Mireles, Acee, & Gerber, 2014). Hot topics discussions were, "dedicated to discussing common misconceptions and misunderstandings of mathematical topics covered that week by using alternative approaches than those used in the classroom" (p. 27). The instructors conducted a backward design of the curriculum to align remedial mathematics courses with their corresponding, credit-bearing mathematics courses and provided "just in time" remedial mathematics curriculum in tandem with credit-bearing courses. Students were required to attend mathematics tutoring and participate in cooperative learning groups. Mireles et al. (2014) reported that remedial mathematics participants at a four-year university in Texas who were in the FOCUS treatment group earned "a greater percentage of A-C grades than the comparison group and were less likely to withdraw from their college algebra course compared to students in the baseline comparison group" (16.4% vs. 6.3% respectively; p. 29). Although the study revealed that male students and older students were more likely to withdraw, there were, “no statistically significant effects of ethnicity on course withdrawal” (p. 29), and overall, the FOCUS Intervention resulted in “statistically significant improvements to mathematics proficiency” (p. 30).

A third example of a promising systemic reform initiative is the M.Y. Math Project which focused on instructional reforms at 4-year colleges (This project was funded by the US Department of Education's Fund for the Improvement of Postsecondary Education). M.Y. Math incorporated mentoring for graduate student instructors; created an instructor handbook; implemented instructor journaling and reflections on pedagogical decisions and classroom observations; developed workshops and demonstrations of non-traditional lesson instruction and provided diversity training and weekly seminars throughout the semester for instructors. Staff professional development focused on the Algorithmic Instructional Technique (AIT) to increasing fundamental and problem-solving skills as measured by the Texas Academic Skills Program (TASP) assessment. Vasquez (2004) found that participating schools showed statistically significant increases in TASP scores and an increase in pass rates in the participants' next mathematics courses (p. 194).

Intrapersonal Factors

While structural and curricular arrangements clearly are important to improving persistence and success, the students themselves, and their sense of agency and self-efficacy, also needs to be considered. For example, while it is clear that there are relationships between mathematics socializations, persistence, and success, it is not clear what triggers undergraduates in remedial mathematics to exhibit productive agency when faced with negative experiences. Hall and Ponton (2005) found that undergraduates in remedial mathematics had low self-efficacy in mathematics. They claimed, “[p]ast experiences, often times failures, in mathematics usually dictate student opinions concerning their perception of personal ability in mathematics as well as their optimism about career choices for which mathematics is the basis of the curriculum” (p. 30). However, Acevedo-Gil et al. (2015) discovered that, despite adverse effects of academic invalidation, participants in their study exhibited productive agency and resilience by "creat(ing) supportive networks in response to instructors who had invalidating pedagogies” (p. 110).

A student’s cognitive strategies, beliefs, motivations and academic behaviors impact their success in remedial mathematics, and these can differ based on race. Zienteck, Ozel, Fong, and Griffin (2013) explored the impact self-beliefs had on the achievement of students enrolled in remedial courses. They found that attendance, "high scores on cognitive strategies” (p. 1002), and beliefs in: resource management strategies; motivational strategies; self-regulated learning; and meeting others’ expectations were significant predictors of achievement in remedial mathematics. Fong, Zientek, Ozel, and Phelps (2015) examined ethnic differences in self-belief and their effect on achievement in remedial mathematics at community colleges ($n=804$) and found that “African Americans self-reported greater efficacy in learning strategies than White and Hispanic students, regardless of academic course grade" (p. 55). For White students, "efficacy of cognitive strategies, motivational strategies, and self-regulated learning strategies predicted higher grades, whereas, for Hispanic students, only self-regulated learning strategies was a significant predictor" (p. 55). They concluded that, “some students probably are not accurate in evaluating their efficacy of learning strategies” (p. 66) and argued for future research on, “the socialization process, classroom environment, instructional methods, and academic tasks (in addition to) factors within ethnicity” (p. 69). Zienteck, Schneider, and Onwuegbuzie (2014) found that remedial mathematics instructors attributed situational factors, such as a student’s family or work responsibilities, and academic behaviors, such as attendance or study skills as having the most significant impact on student performance in remedial mathematics. In response to their findings, Zienteck et al. (2014) recommended that institutions develop interventions designed to help students manage their non-academic responsibilities (p. 80).

As noted above, students’ racial identities are important. Larnell (2011) examined the mathematics identities of African American students enrolled in remedial mathematics courses at a highly selective, four-year university. Using ethnography, interview, and observational data, and an *Identity as Narrative* framework, Larnell found that students' recognized and actively negotiated "identity contingencies in the environment in the forms of master narratives about African American participation in mathematics education settings" (abstract). Identity contingencies, "are the possible judgments that we face in particular social situations" (Larnell, 2011, p. 160). He argued, that "these predicaments…mediate the relationship between who we are and how we enact our ‘projects'" (Appiah, 2005, p. 66 cited in Larnell, 2011, p. 160). In addition, identity contingencies mediate a student's identity and how (or whether) she engages in and with mathematics. This theory, coupled with differential socializations, helps to explain the variability in agency, persistence and success found within ethnic groups.

Implications for the Current Study

Numerous studies examine the effects of mathematics remediation and the impact that remedial mathematics interventions have on persistence and success outcomes. Collectively, these findings confirm that students in university remedial mathematics have differential experiences and outcomes that are racialized. In addition, the findings point to specific contextual factors that hinder or support those minority students, particularly African American and Latinx students, who comprise the majority of the student population in remedial mathematics classroom. The contexts that are most supportive of these students are accelerated remedial courses/programs, culturally responsive and engaging learning environments that foster a sense of community, institutional supports that foster academic and social integration, and caring teachers who are seen as academic resources. Independently, the majority of existing research examines one specific context and whether or not it influences remedial mathematics students' persistence and success, such as learning communities (classroom context) or accelerated courses (institutional context). Only Larnell (2011) examined the persistence and success of university remedial mathematics students by situating the students' experiences within their complex and interrelated sociohistorical/racialized, institutional/classroom, community and intrapersonal contexts. Larnell's (2011) findings confirmed that African American students in undergraduates remedial mathematics are confronted with and challenged by dominant deficit narratives (stereotypes) that are rooted in social stratification (by race), due to their placement in non-college level/remedial mathematics classes at the university level. Larnell (2011) found that the African American students he studied varied in the ways that they negotiated their individual and mathematics identities when confronted with stereotypes pertaining to African American achievement in mathematics (stereotype threats), and how they responded to stereotype threats impacted their persistence in remedial mathematics. Larnell's (2011) qualitative study on identity threats faced by African American students in undergraduate remedial mathematics closely examined sociohistorical and intrapersonal factors that contributed to the participants' mathematics identities and their persistence and success in remedial mathematics. His findings demonstrated the need for further research on the ways in which institutional/classroom and community contexts contribute to or reduce students' exposure to stereotype threats and create opportunities or barriers to African American students' persistence and success in university remedial mathematics at macroscopic (quantitative) and microscopic (qualitative) levels.

Furthermore, Valentine et al. (2011) have called for an investigation into, "the specific aspects of programs that are associated with program success that investigate the interaction between programs and student characteristics to determine what types of programs are most effective for which students" (p. 214). Fike and Fike (2012) support this call by arguing, "it may be beneficial to craft developmental math courses that target specific student profiles rather than using a 'one size fits all' approach…by identifying the unique needs of remedial students, tailored interventions specifically targeted at these needs may promote greater pass rates in remedial mathematics and lead to improved overall academic outcomes" (p. 8). This sentiment is also echoed by Fong et al. (2015) who called for future research on remedial mathematics to examine, "the socialization process, classroom environment, instructional methods, and academic tasks, (as well as) factors within ethnicity" (p. 69). By applying Martin's Multi-Level Framework for Analyzing

Mathematics Socialization and Identity Among African Americans (2000) into my mixed methods dissertation research, I am attempting to respond to these calls.

CHAPTER 3: Research Design and Methodology

In this chapter, I first present the research context to situation the study and participants. I introduce the university, student body, participants and analytical sample. I also outline institutional contexts such as the structures of the remedial mathematics courses offered by the university under study and the institutional supports that are available to mathematics students at the university. I then discuss the research design and methodology used for the study and establish my rationale for employing this mixed-methods research using Danny Martin's Mathematics Socialization Framework (2000). Finally, I provide an overview of the research design, the guiding research questions, data sources, and the overall data collection and analysis processes. I provide a detailed description of the methodologies employed in the study, describe each of the data sources (institutional, survey, and interview case studies) and present descriptive statistics that were collected and analyzed using the procedures outlined below.

Research Context

Setting

This study took place at a large, primarily residential, more selective four-year university in the mid-Atlantic region (Carnegie Classification of Institutions of Higher Education, 2017). Approximately one in five entering students places into a remedial course each year at this university (Office of Institutional Research, Planning, and Assessment). The sample population included all students enrolled in a remedial mathematics course during the fall semester ($n=486$). The state in which this university is located mandates that all college students earn at least three credits of mathematics to graduate with a bachelor's degree; this is called the Fundamental Mathematics Studies requirement. The state requires undergraduates to have a high school diploma or high school equivalency degree to be eligible for college level mathematics courses, but it gives room for institutions to determine eligibility through evidence, such as testing, previous formal education, examinations, and competencies gained through practical experience, maturity, or other appropriate criteria. This state also allows higher education institutions to award credit hours for prior learning or the demonstration of skills and knowledge in specific areas, based on standardized and institutional examination scores (such as Advanced Placement coursework). The state prevents higher education institutions from including credit awarded for remedial education for graduation credit requirements.

At this university, undergraduates can meet their Fundamental Mathematics Studies requirement by passing a credit-bearing mathematics course. They are excused from the class and awarded credit for their Fundamental Mathematics Studies if they earned AP or IB Calculus credits in high school. Those who have not met this prerequisite are required to take the mathematics placement exam, which was developed by the mathematics department. The results of this exam determine whether a student places into a credit-bearing mathematics course or a non-credit bearing remedial mathematics course. As the state mandate suggests, the university's remedial mathematics courses do not satisfy the Fundamental Mathematics Studies requirement needed for graduation. Thus, students who take remedial mathematics courses will need to pass at least one subsequent credit-bearing mathematics course to be eligible for graduation. Depending on their major, students may also be required to earn a specific grade in their Fundamental Mathematics Studies course (a C or higher) and take additional mathematics courses to meet their programmatic requirements (STEM and finance majors).

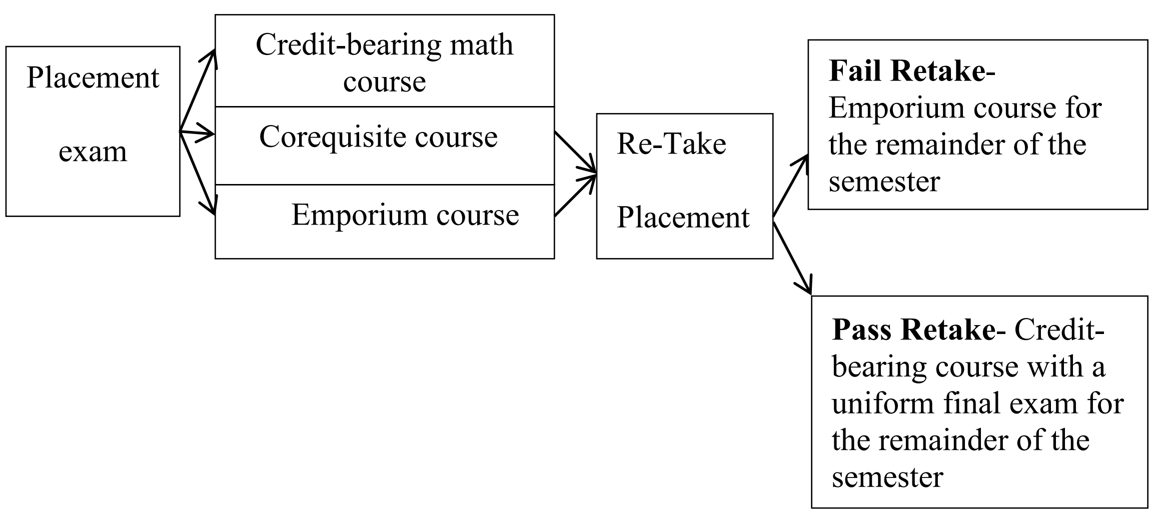
The university requires students to pay for their remedial mathematics courses, although they do not carry any credit towards any degree. Students in the emporium courses are required to pay an additional math fee. Also, students are required to attempt their remedial mathematics course by 30 credit hours and to complete their remedial mathematics courses by 60 credit hours. Therefore, the participant population was constrained to freshman and sophomores. The chair of the corequisite remedial mathematics courses recommended that I study the fall cohort due to the nature of the university's student population, who are predominantly traditional, fall enrollees. Research by Davidson et al. (2015) supports this recommendation.

Remedial Mathematics Courses

The university under study reformed its undergraduate remedial program in 2001. Before these reforms, students who placed into remedial mathematics had slower graduation rates and lower course completion rates than their peers (Gulick & Franklin, 2011). In 2000, a task force was developed to examine the existing remedial program and make recommendations for revising it. As a result, in 2001, the university rolled out a two-part remedial mathematics program that consisted primarily of corequisite mathematics courses. In their corequisite model (Probability, Statistics, College Algebra, or Pre-Calculus), students who score in the upper 50 to 60% of those who do not place into a credit-bearing mathematics class, place into hybrid paths. These paths begin with five weeks of daily mathematics remediation for intermediate algebra skills. At the end of the five weeks, students re-take the faculty developed placement test, to determine whether they will move forward with their first credit-bearing college mathematics course. In a 2012 Complete College America report, over 80% of students in the corequisite classes at this university passed their placement exam at the 5-week mark and continued the semester with their credit-bearing mathematics courses.

For example, a student who places into the corequisite Pre-Calculus course will work to master their intermediate algebra skills for the first five weeks in the course. After those five weeks, she will re-take the placement exam. If she passes, she will remain in the same class, as it transitions to the credit-bearing pre-calculus course for the remainder of the semester. If she also passes the Pre-calculus portion of the course, she will complete her remedial mathematics requirement and earn her Pre-calculus mathematics credits in one semester; thus, she will have met her state-mandated Fundamental Mathematics Studies requirement. Final exams in the hybrid and non-hybrid credit-bearing courses are the same, and "students from the hybrid (developmental) portion have at least as much success on the uniform final as students from the regular (non-developmental) class" (Gulick & Franklin, 2011; figure 2).

FIGURE 2: MATHEMATICS COURSE PATHWAYS



Students who score at the bottom 40 to 50% on their placement tests place into an emporium mathematics program. Under the emporium model, students receive mathematics remediation through a computerized program for 6 hours a week. This program is self-paced and monitored by an instructor in a computer lab setting. Students who achieve mastery of their required mathematics skills within the five weeks re-take the placement exam to try to place into a credit-bearing mathematics class. Those that quickly move successfully through their required modules can also move into a corequisite course with an instructor's recommendation. Students in the corequisite courses who do not pass their five-week placement exam move into the emporium course for the remainder of the semester. Given the structures of the corequisite and emporium models, students in the corequisite classes have a high probability of earning mathematics credits their first semester, but students in the emporium program have a much lower likelihood of earning mathematics credits in their first semester. The structural differences between these two remedial mathematics pathways are essential to note because, as discussed in Chapter 2, prior research indicates that institutional structures that support undergraduates' ability to earn mathematics credits in a reduced time frame (accelerated courses) have positive effects on their persistence and retention (Carnegie Foundation for the Advancement of Teaching, 2014; Tennessee Board of Regents, 2016).

Institutional Math Supports

This university offers a variety of mathematics supports for students on campus, including free tutoring by mathematics faculty and graduate students, peer and private tutoring. University officials report that, in addition to receiving traditional course advising by guidance counselors, remedial mathematics instructors are aware that students sometimes enroll in mathematics courses that are not required by their major. Therefore, remedial mathematics instructors review their students' majors to ensure they are enrolled in the correct remedial mathematics courses. For example, a student enrolled in the corequisite Pre-calculus course may only need College Algebra to meet their Fundamental Mathematics Studies requirement for their major. Thus, the instructor would help the student move to the corequisite College Algebra course. Finally, there are a variety of campus programs (such as TRIO and athletic programs) that offer additional mathematics, academic and social supports.

Setting Rationale

I selected the setting for this study for three reasons. First, there is a general lack of research on undergraduates enrolled in remedial mathematics at selective four-year colleges. Second, there are two very different remedial mathematics models offered by the institution-the corequisite model which has shown significantly higher completion rates than traditional remedial programs, and the emporium model, which has had mixed results, across the nation (Bassett & Frost, 2010; Belfield, Jenkins, & Lahr, 2016; Bonham & Boylan, 2012; Palmer, 2016; Tennessee Board of Regents, 2016). This setting allows for a comparative study of students' experiences, intrapersonal contexts, persistence and success rates, given the remedial mathematics model in which they are placed. Finally, two recent studies have reported that this university has higher than average success rates for students enrolled in their remedial mathematics programs (CCA, 2012; Shearn et al., 2005). Identifying factors that contribute to these success rates would be a valuable contribution to the research on remedial mathematics and would be of interest to colleges and universities across the nation.

In their 2005 report, Shearn et al. found that in the emporium courses, 20% of students came to the university with anywhere from 3-24 Advanced Placement credits (across subject areas), 5% of the students took Calculus in high school, 27% took Pre-calculus in high school, and 45% did not receive any math their senior year. Also, students who entered mathematics through the university's emporium courses earned final grades nearly equal to their peers in their credit-bearing, College Algebra course. Furthermore, graduation rates were roughly equivalent for Black and White students in these courses. This finding countered the overall university graduation rates which showed disparities among racial groups. Finally, more students entered and graduated from the Engineering and Computer, Math, and Physical Science Schools under this revised remedial mathematics program (Shearn et al., 2005). The findings from Shearn et al. indicated that systemic reforms in remedial mathematics have the potential to repair cracks in the STEM pipeline. Given Shearn et al.'s findings, it seemed appropriate to consider researching this university, the students and the school context, the ways they interact, and how they support students' persistence throughout remedial mathematics and success in subsequent credit-bearing mathematics courses.

Pilot Study

Survey Instrument Development

A survey instrument was developed, tested and refined for this study over a period of two years (see Appendix A). I validated the survey items through an extensive literature review, peer review, and the vetting of the items to experts on the undergraduate population at the university, remedial mathematics and mathematics education. More specifically, in the fall of 2014, I engaged in a small qualitative study ($n=3$) on freshman and sophomores' mathematics socializations at the selected university, using Danny Martin's Framework for Analyzing Mathematics Socialization and Identity among African Americans (2000) as my theoretical and analytical framework. Before launching this pilot study, I drafted the survey. Survey items were developed out of Martin's (2000) interview questions pertaining to intrapersonal forces, as outlined in his Mathematics Socialization Framework: students' motivations and goals; their perceptions of their school climate, peers and teachers; their beliefs about their mathematics abilities and motivation to learn, and their beliefs about the instrumental importance of mathematics knowledge. I also included questions about perceptions of differential treatment in mathematics-related contexts and students' access to, and use of, school-based support systems. This form of item development was appropriate for three reasons: I was asking similar research questions about a different population; I was using the same theoretical framework to guide the research; and I could compare the results of my study with those of Martin's (Czaja, & Blair, 2005, p. 20).

After I drafted the survey items, I pre-tested them on the three participants involved in my case study research. Two participants were freshman African American females enrolled in the corequisite College Algebra course, had passed into College Algebra at the 5-week re-take, and were in the Academic Achievement program. One participant was an Asian male (sophomore) who was enrolled in Multivariable Calculus. He was not supported in his mathematics by a specific university program. At least a week before interviewing the participants, each of them received an electronic copy of the first draft of the survey. Each participant went through the survey and answered the questions, annotating items to note issues about their intent, clarity, redundancy, and relevance. I reviewed their comments and made appropriate revisions. During the subsequent case study interviews, one portion of each participants' first interview was dedicated solely to cognitive interviews regarding the survey items. Each participant reviewed the answers they provided and discussed the annotations they made with me at length (Czaja & Blair., 2005, p. 22). As a result of these cognitive interviews, each *annotated* survey item was modified to improve clarity and relevance and to reduce redundancy (Czaja & Blair, 2005, p. 22).

I then shared the revised survey with fellow graduate students and professors who were either in the field of mathematics education or had the first-hand experience with the population under study. During this round of survey development, annotated feedback on the survey questions and demographic items were used to improve item clarity further and to capture the intended demographic data. This second round of revisions led to a third survey draft.

Survey Pilot

I piloted the third draft of the survey in the fall of 2015 to a subgroup of freshman and sophomores enrolled in both remedial and credit-bearing mathematics courses at the university under study (*n=80*). The administrator of the survey noted questions that arose as participants completed them. I used this feedback to improve the items further. For example, students pointed out that the question about financial motivation was ambiguous and could refer to either current finances or post-degree finances. Thus, this item was changed from *finances* to *financial aid* to convey the intent of the question better.

After receiving the completed surveys, I ran a descriptive analysis of each survey item. Each item had variability in the responses, except the question that referred to how motivated students were by grades. As stated previously, each of the survey items was designed to align with the Martin's (2000) mathematics socialization constructs: students' motivations and goals; their perceptions of their school climate, peers and teachers; their beliefs about their mathematics abilities and motivation to learn, and their beliefs about the instrumental importance of mathematics knowledge. I also ran KMO and Bartlett's tests to determine whether it was appropriate to run a factor analysis on these constructs. KMO and Bartlett's values all indicated a factor analysis might help analyze the data ($KMO > .5$; $Bartlett's\ \alpha < .05$). Therefore, I ran an exploratory factor analysis for each construct to examine the correlations of the items and the value of the correlations. When appropriate, I ran a Varimax rotation with Kaiser Normalization. The factor analysis indicated that each item had a correlation coefficient with an absolute value greater than .4. In this final round of revisions, I removed one question from the piloted survey, the motivational question *Grades (general*).

Final Survey Instrument

I administered the final survey (see Appendix A) to the participants in this study in the fall semester before their 5-week placement test re-take. The pilot study improved the survey items, but the original constructs remained intact. The first section of the survey contains questions relating to students' personal goals and motivations. A 5-point scale Likert Scale of importance from "Not at all" (1) to "Extremely important" (5) was used to rate these items. The second section of the survey contains items relating to students' beliefs about their mathematics abilities and motivation to learn mathematics. The third section of the survey contains items pertaining to students' perceptions of their school climate, peers, teachers, and differential treatment in mathematics related contexts, and the fourth section contains items relating to productive persistence, agentive behaviors that have been shown to support persistence and success in remedial mathematics courses (Merseth, 2011). Sections II through IV were also on a 5-point scale, but this scale measured the participants' level of agreement, ranging from "Strongly Disagree" (1) to "Strongly Agree" (5).

I also included demographic questions that were not obtainable by the mathematics department in the final survey. The demographic questions provided me with information regarding the participants' socioeconomic status (Pell Grant and financial aid status), their parents' highest level of education, their English language proficiency, their high school information, their last high mathematics course, whether they studied for their placement exam, and whether they felt their high school mathematics courses prepared them for their placement exams. These items were added because research indicates these factors can significantly predict persistence and success (Bailey, 2009a; Harwell et al., 2014; Melguizo et al., 2014; Valentine et al., 2011).

I aligned each research question with the survey sections. Survey data from Section I answered sub-question a, (e.g., "How important is the emotional and motivational support of your instructors?". Survey data from Section II was answered sub-question b (e.g., "I am a top student in my mathematics class."). Section III answered sub-question c (e.g., "My teacher makes me feel welcome in math class."), and Section IV answered sub-question d (e.g., "My math success is important for obtaining my career goals"; see Appendix C).

Overview of Mixed Methods Design

The primary research question that guided my research was: *"How do sociohistorical, intrapersonal, and institutional factors relate to the persistence and success of undergraduates enrolled in remedial mathematics classes at a university?"* For this study, the term intrapersonal forces refer to: the participants' motivations; their perceptions of their school climate, peers, and teachers, and their beliefs about the fundamental importance of mathematics, their mathematics abilities, and their motivations to learn mathematics. The term persistence refers to the participants' successful completion of their remedial mathematics requirements, and the term success refers to participants passing their subsequent credit-bearing mathematics course, with the minimum grade required for their major. Sub-questions that addressed in this study include:

a. What personal goals and motivations are important to undergraduates enrolled in remedial mathematics courses?

b. What do they believe about mathematics and their mathematics abilities?

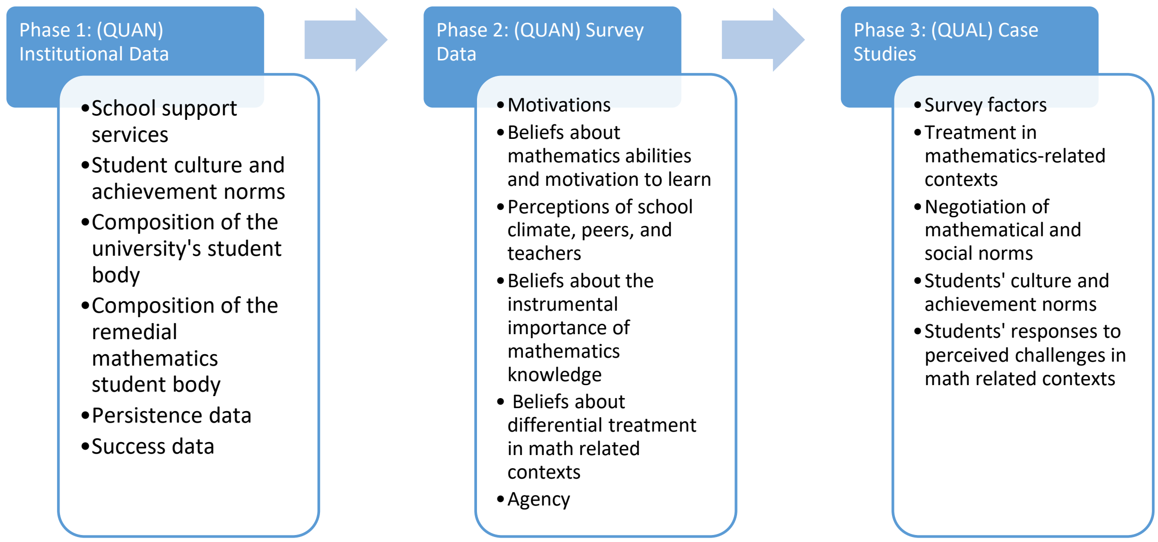
c. What are their perceptions of the school climate, their peers and teachers in mathematics contexts?

d. What motivates their learning of mathematics?

e. How do they express agency in response to perceived opportunities and challenges related to their remedial mathematics courses and requirements?

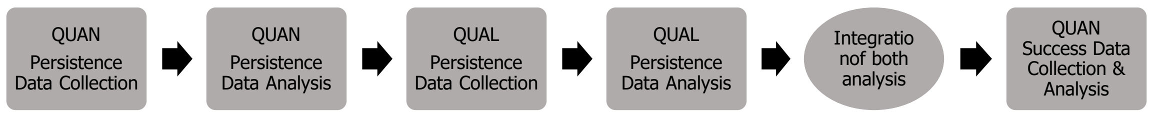
These sub-questions align with individual and classroom contexts that have implications for persistence and success in mathematics (Martin, 2000). Each sub-question was investigated using survey and interview data. Survey and interview questions also examined the participants' perceptions of differential treatment in mathematics related contexts and university and remedial mathematics achievement norms (see figure 3). Institutional data were reviewed to identify available mathematics supports, student achievement norms, and the composition of the university and remedial mathematics student bodies.

FIGURE 3: QUANTITATIVE AND QUALITATIVE DATA SOURCES



This dissertation study began with quantitative data collection, using a Likert-type instrument that was validity and reliability tested and piloted. Departmental data was also collected from the entire remedial mathematics student population at the university under study (*n=486*). Then, I ran a quantitative analysis of the sample data (*n=316*) which included descriptive statistics, correlation analysis, factor analysis, logistic regression, and extreme case analysis. The quantitative persistence findings led to the identification and selection of five 'perceptions of teacher' cases who were interviewed to gather qualitative data. This interview data was thematically coded and analyzed. Then, the two streams of data (quantitative and qualitative) were integrated into a joint display to develop a complete understanding of the phenomena (Lee & Greene, 2007). The success data was then analyzed quantitatively, in light of the integrated persistence findings. Figure 4 is a diagram of the procedures for data collection and analysis.

FIGURE 4: SEQUENTIAL MIXED-METHODS RESEARCH DESIGN (adapted from Creswell, 2015)

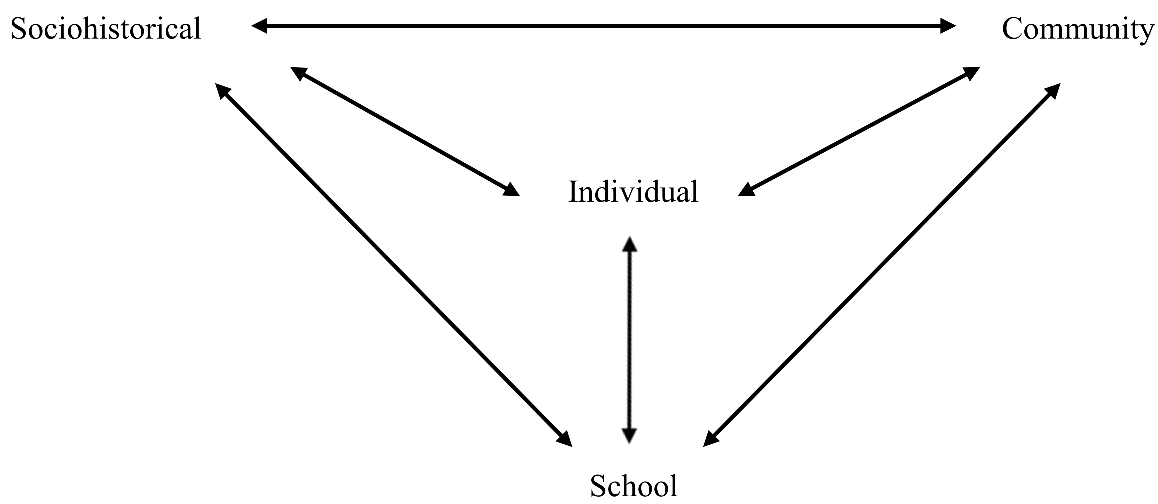


Rationale for Mixed Methods Design

Again, this mixed methods dissertation study builds off of a small pilot study that I conducted on two freshmen and one sophomore undergraduate in the fall of 2014. During this pilot study, I learned that undergraduate students had a variety of strategies for persisting in their mathematics courses when challenged by them. These strategies were related to resources the participants identified as motivators in their survey responses. For example, Joy (pseudonym) did not have a positive mathematics identity or positive mathematics experiences in her remedial mathematics course, but she had a robust academic identity which she attributed to her work ethic, desire to obtain her degree, and her mother. When faced with challenges in her remedial mathematics class, Joy actively sought out the support of her mother and university supports, such as tutoring and meetings with instructors. She attributed her persistence through her remedial mathematics class and her ability to successfully pass her subsequent credit-bearing mathematics class to these motivators (Stoltz & Bowen, 2016). Similar to Martin's (2000) findings on African American high school students, through the pilot study, it became clear to me that two students with similar demographic and mathematical backgrounds could perceive and experience the same mathematics class entirely differently. This finding reinforced the complexity of the relationships Martin examines in his Framework for Analyzing Mathematics Socialization and Identity Among African Americans (2000) and led me to wonder about the strength and consistency of these relationships among students enrolled in remedial mathematics courses at the university under study.

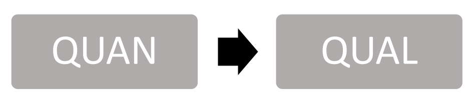
As previously discussed in Chapters 1 and 2, Martin (2000) posited that students negotiate their mathematics identities within a variety of contexts. For example, the broader sociohistorical contexts impact school contexts, which impact the individual’s experiences, beliefs and perceptions about mathematics (figure 5). Likewise, an individual's prior mathematics experiences help her to form beliefs that impact her perceptions of her school, classroom, teacher, and peers in mathematics related contexts. Martin applied his Mathematics Socialization Framework (2000) to his qualitative research on the persistence of African American high school students. Larnell (2011) incorporated Martin's Mathematics Socialization Framework (2000) in his qualitative dissertation study on remedial mathematics students at a 4-year university. By employing Martin’s framework in a mixed methods study of undergraduate students’ in remedial mathematics, I hoped to add to our current understandings of the factors that impact the persistence and success of remedial mathematics students at 4-year universities. Also, I hoped to identify whether employing the framework quantitatively could improve our ability to predict and support the persistence and success of undergraduates who enrolled in remedial mathematics 4-year universities. While the focus of this study is on the relationships between intrapersonal factors (motivations, beliefs, and perceptions), student persistence and success within the school context, I recognize that community and broader sociohistorical contexts are also significant contributors.

FIGURE 5: ADAPTATION OF MARTIN'S (2000) INDIVIDUAL AGENCY AND MATHEMATICS SOCIALIZATION DIAGRAM (p. 33)



Qualitative research methods are appropriate for exploring complex social phenomena such as those described above, and qualitative data capture participants' voices and views in compelling ways. However, quantitative research methods help examine general patterns and relationships for larger groups of people (Creswell, 2015). Thus, I chose to pursue an explanatory sequential mixed methods design, believing that each strand of research would complement the other and would provide, "a better understanding of the problem than either form of data alone" (Creswell, 2015, p. 2). For this study, I used quantitative data to identify broader patterns of relationships among the intrapersonal factors, demographics, persistence, and success. I used qualitative data to explain the phenomena that were identified by the quantitative analysis (Greene, Caracelli & Graham, 1989). Thus, I saw both the quantitative and qualitative data as equally insightful and valuable (Morse 1991, 2003; figure 6).

FIGURE 6: NOTATION FOR MIXED METHODS DESIGN



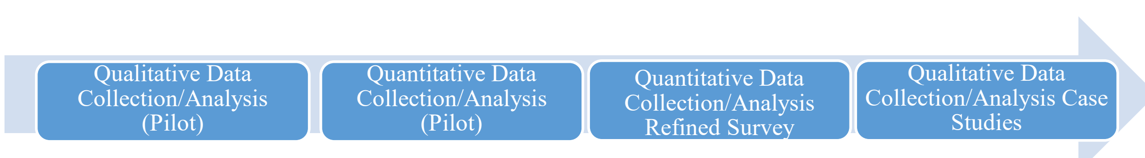
Methodology

The following sections provide an overview of the mixed methods research design employed for this study, includes a description of the quantitative and qualitative data sources (institutional, survey and interview) and a summary of how the data was collected.

Research Design

Again, the explanatory sequential mixed method design discussed in this section was part of a larger multistage mixed methods design (Creswell, 2015, p. 46; figure 7). The first stage of the overall design included the case study interviews and classroom observations that informed the development of the survey instrument items, when coupled with the theoretical framework (Martin, 2000). The two final stages of the mixed methods design are the focus of this dissertation. As noted previously, for these phases of the study, I employed an explanatory sequential design (Creswell, 2015, p. 44-45; recall figure 4), where the quantitative persistence data was first collected using the survey instrument and analyzed to inform the case study selection process. Extreme case selection was used to select the participants for interviews. Interviews were conducted and analyzed before both streams of data were integrated into a joint display. The joint display informed the cross-case analysis and overarching persistence findings. Quantitative success data was then analyzed using descriptive and inferential statistics, in light of the persistence findings.

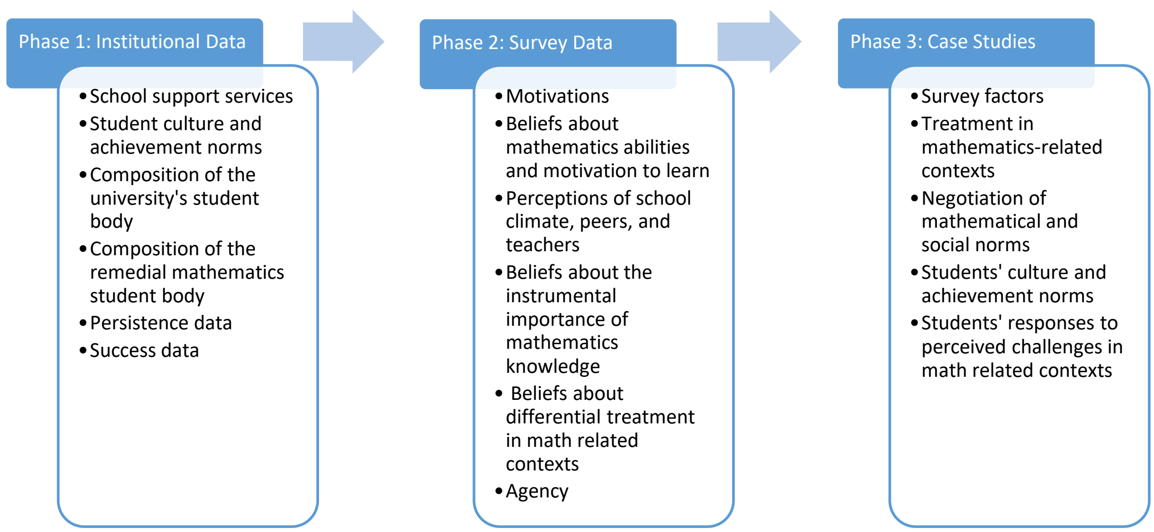
FIGURE 7: MULTISTAGE MIXED METHODS DESIGN



As previously mentioned, there were three sources of data. The first was institutional data. This data was either publicly available through the Office of Institutional

Research, Planning and Assessment (OIRPA), or provided to me by the mathematics department. The second source of data was the survey data. I emailed, or hand delivered the survey to all 486 students enrolled in remedial mathematics courses in the fall. A sample of 316 participants submitted survey data. The third source of data was interview data which was provided by participants who were selected through extreme case analysis (see figure 8).

FIGURE 8: QUANTITATIVE AND QUALITATIVE DATA SOURCES



Institutional data. I collected institutional data from the university's Office of Institutional Research, Planning, and Assessment (OIRPA) report and from the mathematics department. The OIRPA data was publicly available on OIRPA's website. Data collected from this report included the university's classification, as defined by the Carnegie Classification system, and the fall undergraduate population's demographic data, such as race, age, gender, and graduation rates. I obtained demographic data of the students enrolled in remedial mathematics in the fall through the mathematics department. This data included the students' remedial course and section, age, race, gender, and matriculated entry status. The mathematics department also provided me with both the persistence and success data. The persistence data showed whether the students completed their remedial mathematics requirement (pass/fail), was gathered after the completion of the fall semester. The success data, which showed whether the students completed their Fundamental Mathematics Studies requirement (passing with their program's score) was collected after the fall semester and again after the subsequent spring semester. These two points of success data collection were essential because students enrolled in the corequisite courses could have completed their Fundamental Mathematics Studies requirement by the end of their fall semester, while students enrolled in the emporium courses after the 5-week re-take of the placement exam would have been unable to attempt to complete this requirement until the following semester.

Survey data. I administered the survey to all 486 undergraduates who were enrolled in remedial mathematics courses at the university in the fall. With the aid of the remedial mathematics coordinator, all remedial mathematics instructors provided rosters that included the email contact information for their remedial mathematics students. The survey was delivered to all students on the rosters via email, using Qualtrics software. This software allowed me to keep track of which students had completed the online survey. Instructors provided hard copies of the survey to students who preferred to use this method.

The analytical sample consisted of 316 students who completed the survey in the fall (65% response rate). Of these 316 students, 40.2% were enrolled in emporium courses (*n=127*), and the remaining 59.8% were enrolled in a corequisite course: Probability (5.1%, *n=16*); Statistics (2.2%, *n=7*; College Algebra (27.8%, *n=88*), or Pre-Calculus (24.7%, *n=78*). There were mixed response rates in various course sections. The corequisite College Algebra course had an 81% response rate, the corequisite Probability and Pre-

Calculus courses both had a 76% response rate, while only 55% of the emporium and 11% of corequisite Statistics students responded to the survey. The variations in response rates pertained to whether the course instructors' emphasized (or de-emphasized) the importance of their students completing the survey and whether the instructors provided their students with time to complete the survey during mathematics class time.

Interview data. Five 'perceptions of teacher' cases were selected and interviewed, to gain a deeper understanding of the quantitative persistence findings. Cases were selected using extreme case selection (Seawright & Gerring, 2008). The quantitative persistence results identified the factor, 'perceptions of teacher,' as a significant predictor of persistence ($p<.01$). Thus, four extreme 'perceptions of teacher' cases were identified ($\mu\pm1.5s.d.$ - $\mu\pm3.0s.d$) and compared with one mean 'perceptions of teacher' case (within $\mu\pm1.5s.d$). I used semi-structured interviews pertaining to the participants' remedial mathematics classroom experiences, their perceptions of their remedial mathematics teachers, the motivations/strategies they drew upon when faced with challenges in their remedial mathematics courses, and what they attributed to their ability, or inability, to complete their remedial mathematics course requirements (their persistence) to guide the interview discussion (see Appendix B).

The persistence interviews lasted approximately one hour each and follow up discussions was conducted as needed. At the beginning of each interview, I described the goal of my study and my interest in the participant's story. I provided the participants with opportunities to ask questions and select their pseudonyms, and I aligned the semi-structured interview protocol with Martin's framework (2000) and the survey components (see Appendix C).

Observational data. All five remedial mathematics course types were observed once during the fall semester, to obtain contextual classroom data. I used an adaptation of the PORTAAL observation tool (Eddy, Converse & Wenderoth, 2015; see Appendix D) for classroom observations. This tool was designed to capture and assess active learning in STEM classrooms. It is supported by literature on best practices in active learning, is user-friendly, "validated and has high interrater reliability" (Eddy et al., 2015, p. 2). In addition, research indicates there is a relationship between active learning, students' perceptions of their mathematics classes, and their persistence and/or success in remedial mathematics (Amelink, 2005; Hooker, 2011; Hudesman et al., 2014; Mireles et al., 2011; Springer, Stanne & Donovan, 1999; Wladis et al., 2014; Zavarella & Ignash, 2009). The observation tool was used solely to help standardize my discussion on the classroom contexts students were exposed to as they completed their remedial mathematics requirements.

Data Analysis

Data analysis proceeded as outlined in the previous section. I administered the survey, and the corresponding data were collected from the participants before the 5-week placement test re-take. I received the demographic data from the mathematics department a few weeks later and imported it into the survey data set. At the end of the fall semester, the persistence data was also collected from the mathematics department and entered into the data set. As stated previously, persistence referred to the successful completion of remedial mathematics requirements. Once all quantitative persistence data was collected, it was analyzed using descriptive (measures of central tendency, measures of dispersion, and measures of normality) and inferential (exploratory factor analysis, correlation analysis, and regression analysis) statistics. Again, the results of the quantitative persistence data analysis informed the selection of the ‘perceptions of teacher’ cases and the qualitative persistence data collection. I transcribed the qualitative persistence data, verbatim, and qualitative coding incorporated both deductive and indicative coding methods. First, the five EFAs significantly correlated with persistence were used to code each participants' interview data thematically. Once each participants' qualitative findings were organized by theme and codes were examined within each participants’ findings, I integrated the thematically coded data into a joint display. I then examined these codes across the five ‘perceptions of teacher' cases to identify broader themes and sub-themes.

At the end of the spring semester, success data was obtained from the mathematics department and entered into the data set. As stated previously, success referred to passing the following credit-bearing mathematics course with the minimum grade required by the students' major; thus, students identified as successful would have earned their Fundamental Mathematics Studies requirement. I incorporated the success data into the data set and to examine the relationships between the participants' intrapersonal factors, demographics, persistence, and success using the descriptive and correlational statistical procedures described in the persistence data.

Descriptive Statistics

I generated descriptive statistics for all survey items, and all departmentally provided data, including the dependent variables, persistence, and success. Descriptive statistics included measures of central tendency (mean, median and mode), measures of spread (range, variance, and standard deviation) and tests of normality (skewness, kurtosis, Standard Error of the Mean).

Exploratory Factor Analysis

A factor analysis, with a mean replacement for missing values and varimax rotation, was conducted to identify whether the theoretical constructs were unidimensional scales. Unidimensional scales “contribute to the measurement of the particular variable, and only that variable” (Blake, 2003, p. 215). I analyzed items by running a factor analysis on the five theoretical constructs examined in the survey: personal motivations; beliefs about mathematics abilities and motivations to learn mathematics; perceptions of school climate, peers and teachers; beliefs about the instrumental importance of mathematics knowledge, and productive agency.

In addition to identifying unidimensionality, the factor analysis was used to determine whether latent variables in this particular set of data aligned with the theoretical constructs of the framework, and whether the theoretical constructs were composed of subscales (Blaikie, 2003, p. 220). While factor analysis uses correlation coefficients which assumes interval or ratio-level data, "it has become common practice to assume that Likert-type categories constitute interval-level rather than ordinal-level measurement" (Blaikie, 2003, p. 231). Also, although factor analysis assumes normal distributions, I did not transform skewed distributions but opted to accept that the non-transformed correlation coefficients would be a more conservative indicator of relationships among the items (Blaikie, 2003, p. 231). More specifically, the effect sizes of the significantly correlated factors will be conservative.

For factor analysis, sample sizes of at least 300 are generally assumed to provide reliable results (Field, 2000, p. 443 as cited in Blaikie, 2003, p. 221). KMO values of .9 or higher were interpreted as outstanding samples and values of .5 or lower were considered inadequate samples (Blaikie, 2003, p. 221). Only factors with eigenvalues greater than one were considered. Although the minimum factor loading criteria for a sample of 300 is .30 for a level of significance of .01 (two-tailed; Stevens, 1992), I followed Stevens' (1992) recommendation to consider excluding factors with loadings below .40 on the unrotated solutions and used the minimum loading criterion of .50 when examining the rotated solutions (Blaikie, 2003, p. 225). Items above .40 on the unrotated solutions and above .50 on the rotated solutions for more than one factor were considered for exclusion, to preserve unidimensionality (Blaikie, 2003).

Cronbach’s alpha was used to identify the reliability of the scales and items. Items were considered for removal if the alpha coefficient was below .65, as suggested by Campbell et al., (2014). Item to item correlation matrices were examined to identify the strength of the relationships between items, and item to total correlations were used to identify weak items, using a minimum criteria of .50. Items with communalities below .40 were considered for removal during the analysis. After unidimensional scales and subscales were identified, factor analysis was run on eliminated items, using the same methods described above. I also ran excluded item analysis to determine whether additional unidimensional scales existed, using the same techniques described above.

In addition to running EFAs with varimax rotations (with mean replacements for missing values), I also ran EFAs with oblimin rotations and mean replacements for missing values. Although there were slight differences between the loading values of the oblimin pattern matrices and the varimax rotated matrices, the items loaded to the same scales and subscales, and the interpretation of the scales and subscales did not change. For example, for Scale I of Personal motivations, Perceptions, the factor loadings for the oblimin rotation ranged from .622 to .900 for subscale 1, Perceptions of others. These loadings were slightly different from those of the varimax rotation which ranged from .628 to .894. However, each of the four items that loaded onto the subscale in the varimax matrix loaded onto the same subscale in the pattern matrix, in the same rank order. Therefore, I used the regression variables created from the EFA with the varimax rotation in the logistic regression analysis. As the factor analysis is not pertinent to my research questions, I have included the identified themes and subthemes below for reference.

Theme I: Personal motivations; scale 1, perceptions of self and others. Using the EFA methods and criteria outlined above, I conducted a series of analysis on the Personal Motivations items. The results led to the identification of two independent factors. The first factor consisted of four items with factor loadings ranging from .628 to .894. The second factor contained two items with factor loadings of .865 and .855. Altogether, the six items described *Perceptions* with subscale one relating to the perceptions of others and subscale two relating to participants' perceptions of themselves (figure 9).

FIGURE 9: THEME I: PERSONAL MOTIVATIONS, SCALE I: PERCEPTIONS SUBSCALES: OTHERS (1) AND SELF (2)

	Component	
	1	*2*
Peers' perceptions of career choice	*.894*	
Friends' perceptions of career choice	*.870*	
Teacher's perception of career choice	*.794*	
Instructional support from peer	*.628*	
Work ethic		*.865*
Desire for education		*.855*

The KMO value was .704, and communalities ranged from .433 to .810. The alpha coefficient for subscale 1 was .815 and .663 for subscale 2.

Theme I: Personal motivations; scale 2, social integration. The initial round of analysis excluded 13 of the 19 personal motivation items due to their failure to meet the reliability, factor loading, or unidimensionality criteria. These removed items were re-examined using the same set of EFA criteria, to identify whether additional unidimensional scales existed. The results led to the identification of two other unidimensional scales that aligned well with Tinto's social integration framework (1993), as they highlight socio-emotional and academic motivators that impact persistence and retention. Figure 10 presents the first of these scales, *Social Integration*.

FIGURE 10: THEME I: PERSONAL MOTIVATIONS; SCALE II, SOCIAL INTEGRATION

	Component 1
Access to mentors	*.764*
Emotional support of peers	*.737*
Emotional support of math teacher	*.735*
Emotional support of family	*.664*
Community, family, & professional relationships	*.660*
General class experiences	*.658*
Early professional mentoring	*.632*

Item means ranged from 3.343 (‘Emotional support of peers’) to 4.067 (‘Early professional mentoring’), indicating most participants identified these social integration items as ‘Very Important’ or ‘Extremely Important’ motivators. Correlations ranged from .203 (‘Early professional mentoring’ with ‘Emotional support of family’) to .570 (‘Emotional support of peers’ with ‘Emotional support of the math teacher’). The KMO was .840; factor loadings ranged from .632 to .764, and the alpha coefficient was .818.

Theme I, Personal motivations; scale 3, academic integration. The second unidimensional scale that resulted from the excluded item EFA included four items that pertain to academic integration (figure 11; Tinto, 1993). Mean values for these items ranged from 3.707 (‘Math class experiences’) to 4.459 (‘Job guarantee’), indicating that participants also found these academic integration items to be 'Very Important' or 'Extremely Important' motivators. Item loadings ranged from .624 to .757. The alpha coefficient was .669, and item-to-item correlations ranged from .234 ('Job guarantee' with 'Math class experiences') to .431 ('Math grades' with 'Math class experiences'). Communalities ranged from .390 to .573, and the KMO value was .677.

FIGURE 11: THEME I: PERSONAL MOTIVATIONS; SCALE 3, ACADEMIC INTEGRATION

	Component 1
Math class experiences	*.757*
Math grades	*.748*
Instructional support from math teacher	*.686*
Job guarantee	*.624*

Theme II: Beliefs about mathematics abilities and motivation to learn math. Five items loaded onto the 'Beliefs about math abilities and motivation to learn math' scale. Loading values ranged from .687 ('I want more math classes') to .805 (I like math class; figure 12). The alpha coefficient was .803. The KMO value was .775, and communalities ranged from .472 ('I want more math class') to .647 ('I like math class'; figure 12).

FIGURE 12: THEME II, SCALE I: BELIEFS ABOUT MATH ABILITIES AND MOTIVATION TO LEARN MATH

	Component 1
I like math class	*.805*
I am good at math	*.800*
I have a sense of belonging in math class	*.767*
I am a top student	*.700*
I want more math classes	*.687*

Theme III: Perceptions of school climate, peers and teachers. Theme III consisted of 14 items which loaded onto three factors (figure 13). Factor 1 consisted of 7 items that pertained to the participants' 'Perceptions of the teacher' (*Cronbach's alpha of .887*). Factor 2 contained four items that pertained to the participants' 'Perceptions of the school climate' (*Cronbach's alpha of .687*), and factor 3 consisted of 3 items that pertained to the participants' 'Perceptions of their peers' (*Cronbach's alpha of .710*). The KMO value was .851, and communalities ranged from .343 ('I am confident meeting teacher expectations') to .727 ('My math teacher supports my conceptual understanding').

FIGURE 13: THEME III: PERCEPTIONS OF THE TEACHER (1), SCHOOL CLIMATE (2) AND PEERS (3)

	Component		
	1	2	3
My math teacher motivates me to persist in math	*.845*		
My math teacher supports conceptual understanding	*.841*		
My math teacher is welcoming	*.785*		
My math teacher helps me make sense of math	*.734*		
My math teacher believes I can succeed in math	*.709*		
My math teacher understands my learning needs in math	*.696*		
I am confident in meeting teacher expectations	*.574*		
I have positive relationships with peers in math class		*.718*	
I have math support outside of math class		*.709*	
I have positive relationships with peers at school		*.668*	
I feel comfortable asking for and using school resources to succeed in math		*.659*	
My classmates and I have similar beliefs about math			*.805*
My classmates and I have similar beliefs about school			*.781*
My classmates and I have similar beliefs about math class			.693

Theme IV: Beliefs about the instrumental importance of mathematics knowledge. All five items in Theme IV loaded onto one unidimensional scale (figure 14). The correlation coefficients ranged from .203 ('Math helps me understand the world around me' with 'my success in math is important to me') to .659 ('I can apply what I learn in math class to my life' with 'Math helps me understand the world around me'). The KMO value was .751, and communalities ranged from .342 ('My success in math is important to me') to .713 ('Math is relevant to my future career'). Factor loadings ranged from .585 to .845.

FIGURE 14: THEME IV: BELIEFS ABOUT THE INSTRUMENTAL IMPORTANCE OF MATHEMATICS KNOWLEDGE

	Component 1
Math is relevant to my future career	*.845*
I can apply what I learn in math class to my life	*.793*
My math success is important for attaining my career goals	*.759*
Math helps me understand the world around me	*.740*
My success in math is important to me	*.585*

Theme V: Productive agency. Theme V, Productive agency, consisted of 4 items that loaded onto one unidimensional scale as well (figure 15). The alpha coefficient for the scale was .682, the KMO value was .727, and communalities ranged from .456 to .589. Factor loadings ranged from .675 to .768.

FIGURE 15: THEME V: PRODUCTIVE AGENCY

	Component 1
I always complete math homework	*.768*
I seek answers to questions about math	*.723*
Attendance is a priority in math	*.707*
I work through challenges in math	*.675*

In the chapters that follow, the following titles will be used to reference the EFA scales and subscales:

Theme I: Personal motivations

1. Perceptions

    a. Perceptions of others

    b. Perceptions of self

2. Social Integration

3. Academic Integration

Theme II: Beliefs about mathematics abilities and motivation to learn math

Theme III: Perceptions of school climate, peers and teachers

1. Perceptions of the teacher

2. Perceptions of peer relationships and institutional supports

3. Perceptions of classmates

Theme IV: Beliefs about the instrumental importance of mathematics knowledge

Theme V: Productive Agency

Inferential Statistics

Hypothesis testing. A series of hypothesis tests were run to identify whether there were mean differences in persistence and success based on demographic predictors, item responses, or factor scores. These included independent samples t-tests, one-way ANOVAs, Mann-Whitney U tests and Kruskal-Wallis H tests as appropriate. First, the demographic variables, 'English as a first language,' 'Studied for first placement exam,' 'High school math courses prepared me for the math placement exam,' and 'Transferred from a community college' were coded as (0) for no and (1) for yes based on the binary survey responses. Also, 'Gender' was coded as (0) for male and (1) for female, and 'High school' was coded as public (0) or private (1).

When the results of the hypothesis tests indicated no significant differences in persistence or success ($p>.05$), group frequencies and existing research was used to determine whether collapsing some groups/categories would be appropriate. For example, while the participants' ages ranged from 16-65, the majority of students were between 16 and 19. Also, prior research suggests that there are differences in the persistence and success rates for traditional and non-traditional aged undergraduates enrolled in remedial mathematics (Dasinger, 2013). Thus, the resulting age group categories became traditional, '16-19' (0), and non-traditional, '20-65' (1).

I coded the remedial math courses by remedial model, where ‘Corequisite’=1 (110, 111, 113 or 115) and ‘Emporium’=0 (003; Carnegie Foundation for the Advancement of Teaching, 2014; Hern & Snell, 2014; Tennessee Board of Regents, 2016). I coded matriculated entry status as ‘Freshman and Freshman Advanced Studies' (0), or ‘2 or 4 Year Transfer' (1). I coded race/ethnicity as ‘White’ (0); ‘Black/African American’ (1); ‘Latino’ (2); ‘Asian, Native American/Pacific Islander or Multi-racial’ (3). I coded the parent's highest level of education as ‘High school or less’ (0), or ‘Some college or more’ (1). I coded years of high school math as ‘0-3 Years' (0), or ‘4 or More Years’ (1), and I coded last mathematics course was as ‘Algebra, trigonometry, or other’ (0), or ‘Pre-Calculus, calculus, AP calculus, statistics or AP statistics’ (1).

I also coded the participants' college of major into five categories, based on the frequency distributions of each major: STEM (AGNR, ARCH, CMNS, ENGR, INFO and SPHL; 0), non-STEM (ARHU, BMGT, EDUC, JOUR; 1), Behavioral and Social Sciences (BSOS; 2), Academic Achievement Program (AAP; 3), Letters and Sciences (LTSC; 4) and Freshman Connection (FRESH; 5). The two dependent variables, persistence and success were dummy coded as YES (1) or NO (0). Once I coded the demographic predictors, independent t-tests and one-way ANOVAs were conducted to determine whether or not mean differences in persistence and success existed among groups. I included a table of the variable codes for reference (Table 1).

TABLE 1: DEMOGRAPHIC VARIABLE CODES

Variable	**Type**	**Codes**	
English as a first language	Independent	No (0)	Yes (1)
Studied for the placement exam	Independent	No (0)	Yes (1)
High school math courses prepared me for the math placement exam	Independent	No (0)	Yes (1)

Transferred from a community college	Independent	No (0) Yes (1)
Gender	Independent	Male (0) Female (1)
High School	Independent	Public (1) Private (1)
Age	Independent	16-19 (0) 20 + (1)
Math course	Independent	Emporium (0)Co-requisite (1
Matriculated entry status	Independent	Freshman (0) Transfer(1)
Race/ethnicity	Independent	White (0) Black/African American (1) Latinx (2) Asian, Native American/Pacific Islander or Multi-racial (3).
Parents' highest level of education	Independent	High school or less (0) Some college or more (1)
Years of high school math	Independent	0-3 (0) 4 or more (1)
Last mathematics course	Independent	Algebra, trigonometry, or other (0) Pre-Calculus, calculus, AP calculus, statistics or AP statistics (1)
College of major	Independent	STEM (0) non-STEM (1) Behavior Sciences (2) Academic Achievement Program (3) Letters and Sciences (4) Freshman Connection (5)
Persistence	Dependent	No (0) Yes (1)
Success	Dependent	No (0) Yes (1)

Missing case analysis. I also conducted a missing case analysis. I ran multiple independent sample t-tests where each demographic variable was examined using the filter variable 'Responded' to identify if there were mean differences in persistence or success among those students who responded to the survey and those who did not. The results of the independent t-tests indicated there were significant differences between mean persistence rates for responders and non-responders (t=-2.647, df = 267.103, p<.01). However, the missing case analysis indicated the only statistically significant mean difference between responders and non-responders was for the variable 'Current course' (t=-2.647, df =267.10, p<.01). This finding was not surprising given the differences among instructor support that arose when the surveys were administered to the two groups, resulting in low response rates from the 003 students compared with those of the 01x students (55.2% vs. 73.8%, respectively). All other independent t-tests indicated there were no statistically significant mean differences in persistence or success among the responders and non-responders.

Bivariate correlations. After conducting the missing case analysis, I examined the bivariate correlations of the demographic variables with the dependent variable, Persistence, and then examined the bivariate correlations of the intrapersonal factors, that resulted from the EFA, with Persistence. All independent variables, including demographics and EFA scales and subscales, were correlated with Persistence, using the Pearson product-moment correlation coefficient. The results of the correlation analysis informed the independent variables included in the logistic regression analysis. I report on the results in Chapter 4.

Logistic regressions. The descriptive and inferential statistics helped me to identify demographic variables and intrapersonal factors that may have contributed to the participants' persistence. I employed logistic regression to identify whether these relationships could be used to help predict a remedial mathematics student's persistence. Logistic regression was the model of choice because persistence and success were both binary (yes/no or pass/fail). Each logistic regression was run in blocks. First, I regressed the dependent variable persistence on all significantly correlated demographic variables. Next, I regressed persistence on all significantly correlate factors identified through the EFA. Finally, I regressed persistence on the combined demographic variables and factors that were significantly correlated with persistence. The final regression was run in blocks to identify the best fitting model.

A number of tests were conducted to determine good model fit. These include examinations of the change in log likelihood using the likelihood ration test, where the -2 Log Likelihood for the full model was compared with the -2 Log Likelihood for the constant only model, and the corresponding critical chi-squared value, with a degree of freedom equal to the difference between the parameters of the full and baseline model, given an alpha of .05, was compared with the chi-squared value of the full model. For this test, if the chi-squared value was greater than the critical chi-squared value, I rejected the null hypothesis that the baseline model was the best model (Lomax & Hahs-Vaughn, 2012).

In addition to examining the change in log likelihood, I conducted the Hosmer-Lemeshow Goodness-of-Fit test. For this text, I looked for nonstatistically significant results. A nonstatistically significant Hosmer-Lemeshow chi-square value indicated there was no statistically significant difference between the predicted and observed values. Thus, good model fit. I also examined the pseudo variance explained using both Nagelkerke and Cox and Snell R^2 values. Finally, I examined the predicted and observed group membership to identify the percentage of cases correctly classified by the models (Lomax & Hahs-Vaughn, 2012). I present each of the logistical regression models and significance test findings in Chapter 4.

Extreme case analysis. The quantitative data collection and analysis helped me to answer the primary research question, *"How do sociohistorical, intrapersonal, and institutional factors relate to the persistence and success of undergraduates enrolled in remedial mathematics classes at a university?"* and sub-questions a-d. However, the quantitative data was unable to help me fully answer sub-question e, *"How do they express agency in response to perceived opportunities and challenges related to their remedial mathematics courses and requirements?*" or to explain why some of these relationships existed. Thus, in addition to answering sub-question e, additional questions were formulated during the quantitative data analysis which motivated the qualitative data collection methods and procedures:

1g. *Why do the participants' 'perceptions of their teacher' scores help us predict their persistence?*

1f. *In what ways do the participants' beliefs (about their mathematics abilities), perceptions (of their teacher) and motivations (perceptions of others, academic and social integration) inform our understanding of the barriers and opportunities that impact their persistence in their remedial mathematics courses?*

Through the quantitative persistence findings, I identified the factor, 'perceptions of the teacher' as the only significant intrapersonal predictor of persistence. Thus, the 5 cases used for the qualitative data collection and analysis were selected using 'perceptions of teacher' scores (figure 16). First, I selected three participants with various levels of extreme 'perceptions of teacher' scores (Edna, Sparrow, and Alana; from $\mu\pm1.5$s.d. to $\mu\pm3.0$s.d.) and one mean 'perceptions of teacher' participant (Ellie). It is important to note that there were no positive perception of teacher scores, so I expected the case study findings would be reflective of the skewed perception of teacher scores. Also, for this study, scores that fell within 1.5 standard deviations of the mean ‘perceptions of teacher’ score were considered to be within a normal range.

FIGURE 16: ‘PERCEPTIONS OF TEACHER’ CASES (PERSISTENCE)

Case (pseudonyms)	percteac	gender	race	highest level of ed of guardian	last math course	developmen	Persistenc	Success	College
Within μ±1.5*s.d.*									
Ellie	-1.192	female	Black/African America	Some college or more	Pre-Calculus, calculus, AP calculus, statistics or AP statistics	corequisit	Yes	Yes	STEM
Outlier μ±1.5*s.d.*									
Edna	-1.7112	female	Black/African America	High school or less	Pre-Calculus, calculus, AP calculus, statistics or AP statistics	corequisit	Yes	Yes	Business
Outliers μ±2.5*s.d.*									
Marcus	-2.6849	male	Black/African America	Some college or more	Algebra, trigonometry, other	emporium	Yes	No	ACA ACH PROG/STEM
Sparrow	-2.935	male	Black/African America	High school or less	Algebra, trigonometry, other	emporium	No	No	ACA ACH PROG/STEM
Outlier μ±3.0*s.d.*									
Alana	-3.3098	female	Multiracial	High school or less	Algebra, trigonometry, other	emporium	No	No	non-STEM

The first 4 cases were selected randomly from within their corresponding ‘perceptions of teacher' group, a fifth ‘perceptions of teacher' participant (Marcus) was purposefully selected. Marcus and Sparrow had similar ‘perceptions of teacher’ scores that fell below 2.5 standard deviations of the mean, and they had similar demographic data, but Sparrow did not persist, and Marcus did. In fact, of all the participants with extreme ‘perceptions of teacher’ scores, Marcus was the only participant enrolled in the emporium course who persisted. Marcus was identified as an outlier during the logistic regression analysis, as he was the only participant who persisted when predicted not to. Thus, Marcus was a purposefully selected for the qualitative portion of the study. These 5 ‘perceptions of teacher’ cases were a mix of male and female students (2 and 3, respectively) enrolled in both the emporium and corequisite remedial mathematics courses (3 and 2, respectively), and all were students of color. Also, these students represented four of the five college categories used in this study: STEM, non-STEM, Behavior Sciences, and the Academic Achievement Program.

Alana was the most extreme 'perceptions of teacher' case out of all participants (-3.30978). She was a multi-racial female, enrolled in the emporium remedial mathematics course, whose primary guardian had completed high school or less, and she was a non-STEM major. She did not persist or succeed. Marcus and Sparrow both had an extreme perception of teacher scores that fell below 2.5 standard deviations of the mean. They were both Black males who placed into the emporium remedial mathematics course, and they were both affiliated with the Academic Achievement Program. Also, both Marcus and Sparrow took Algebra, trigonometry or another non-calculus or statistics course in their last year of high school, Marcus persisted, while Sparrow did not. For these two cases, only the parents' highest level of education differed. Also, while Edna fell outside of 1.5 standard deviations from the mean for 'perceptions of teacher,' her demographic data appeared to be much like Ellie's. Both were Black females, enrolled in a corequisite course, had pre-calculus or higher as their last high school mathematics class, and both persisted (and succeeded). Edna and Ellie appeared to only differ by their choice in major (Business versus STEM) and their parents' highest level of education.

Qualitative Analysis

To gain a deeper understanding of how 'perceptions of the teacher' impacted the participants' persistence, I interviewed each of the 5 'perceptions of teacher' cases individually. I audio-taped every interview and hired a transcription service to transcribe the interviews verbatim. At the beginning of each interview, I reviewed the risks, benefits and confidentiality procedures for the study that were discussed prior to their completion of the survey. I also provided each participant with the opportunity to select a pseudonym for themselves. I then shared information about myself and why I was particularly interested in hearing about his or her experiences in their remedial mathematics courses and at the university. Finally, I provided each participant with the opportunity to ask me questions or voice any concerns before beginning the audio-recording of the interview.

For the first round of qualitative data analysis, I coded the interview data deductively using the factors significantly correlated with persistence as themes. These factors were: their perceptions of the teacher ($r = .169, p < .01$), beliefs about mathematics abilities and motivation to learn mathematics ($r = .116, p < .05$), and the three motivation items: perceptions of others ($r = -.143, p < .05$), academic integration ($r = -.163, p < .01$) and social integration ($r = -.177, p < .01$). I first color-coded the thematic data by hand on hard copies of the transcripts. After this initial round of coding, I color coded the electronic version of the transcripts thematically. By coding both the hard and electronic copies of the transcripts, I was able to confirm coding consistency within and across the participants' data.

For example, in the first round of deductive thematic coding, Ellie responded to the question, "What (math supports) are available to you?" by referring to her inability to take computer science courses or obtain supports offered within the computer science program:

> I think it was different in my experience because of being placed in 003, and because of that, I wasn't able to take any computer science courses anyway. So, I was just taking gen ed, so I kind of like, I had declared my major as comp sci, but I wasn't doing anything with

> comp sci…most of, like, the math help and like, comp sci help that you get is for your, like, required comp sci class…to like…complete your major or the requirement [00:08:00].

During hand coding, I identified the example above as aligned with the theme 'perceptions of academic integration,' as Ellie was explicitly referring to her inability to participate in tutoring or coursework for computer science majors. My electronic coding of this excerpt matched my hand coding, so I integrated this data with the corresponding quantitative data in a joint display that was organized by participant and theme.

Next, the spreadsheet of thematic codes was examined for each of the participants individually. While reviewing each participants' thematically coded data, I developed analytical memos to piece together each participants' demographic, 'perceptions of the teacher' and thematically coded interview data. This compiled data was used to situate the participants within the university and remedial mathematics settings and develop each of the participant's narratives. Once I drafted each participant's narratives, I looked across the participants' integrated data that was organized in the joint display to inductively develop codes representing broader themes that I identified across the five cases. Through code weaving (Saldana, 2016) of the integrated data from the joint display, I developed a set of theories and assertions about the relationships between the participants' intrapersonal factors, personal experiences, persistence, and success. These theories were vetted and refined three times before I arrived at three final assertions: the more extreme the participants' perceptions of their remedial mathematics teacher, the more likely they were to describe their challenges in their emporium remedial mathematics class to specific teaching practices versus general issues with the course structure; STEM participants had differential experiences in their emporium remedial mathematics courses that were triggered by institutional barriers that compounded the negative effects and impacts pertaining to remedial mathematics course placement, and finally, that participants who were successful in their emporium remedial mathematics courses were able to leverage intrapersonal and institutional assets that were supportive of their persistence. These findings are presented in detail in Chapter 5.

In the next two chapters, I outline my findings that resulted from employing the methods described above. In Chapter 4, I present my quantitative persistence and success findings, and in Chapter 5, I present my qualitative persistence findings. The dissertation concludes with Chapter 6, a discussion on the integrated findings, the affordances and limitations of the study and implications for future research.

CHAPTER 4: Quantitative Findings

In this Chapter, I discuss the significant findings that resulted from the descriptive, exploratory factor and logistic regression analyses. After sharing the results of these quantitative analyses, I introduce questions that arose from the quantitative findings that warrant the qualitative portion of the study presented in Chapter 5. Again, the primary research question that guided this study was *"How do mathematics experiences and intrapersonal forces relate to the persistence and success of undergraduates enrolled in remedial mathematics classes?"* Sub-questions were:

a. What personal goals and motivations are important to undergraduates enrolled in remedial mathematics courses?

b. What do they believe about mathematics and their mathematics abilities?

c. What are their perceptions of the school climate, their peers and teachers in mathematics contexts?

d. What motivates their learning of mathematics?

e. How do they express agency in response to perceived opportunities and challenges related to their remedial mathematics courses and requirements?

As this study was framed by an adaptation of Martin's Multilevel Framework for Analyzing Mathematics Socialization and Identity Among African Americans (2000), the primary research question and sub-questions were aligned with the components of the framework outlined in Chapters 2 and 3. Also, the terminology aligned with Martin's (2000). Specifically, the term intrapersonal forces referred to the participants' motivations; their perceptions of their school climate, peers, and teachers, and their beliefs about the fundamental importance of mathematics, their mathematics abilities, and their motivations to learn mathematics. The terms persistence and success were defined by existing research on persistence and success of undergraduates enrolled in remedial mathematics courses. Thus, in what follows, *persistence* refers to the participants' successful completion of their remedial mathematics requirements (by the end of the fall semester). The term *success* refers to participants passing their subsequent credit-bearing mathematics course (by the end of the academic year), with the minimum grade required for their major. These definitions imply that a student would need to persist (pass remedial mathematics) in order to succeed (pass their subsequent credit-bearing math class). While the corequisite courses provide the opportunity for students to persist and succeed in the same semester, a student in an emporium course would need to move into corequisite within the first five weeks of the semester in order to do so. Thus, it is potentially more difficult for emporium students to succeed by the end of their first semester enrollment in remedial mathematics. The quantitative findings discussed below helped to answer the primary research question and sub-questions a-e.

Overview of the Quantitative Results

This section provides an overview of the main quantitative results presented in the sections that follow. As a group, at 92% across the two types of courses, the participants had high rates of persistence. Moreover, their persistence was associated with several intrapersonal factors (such as their perceptions of their teacher) as well as institutional and socio-historical factors (such as their placement into corequisite versus emporium courses and their access to higher level mathematics in high school). The most significant institutional factor was placement into a corequisite versus an emporium remedial mathematics course. The corequisite students in this study had nearly a 100% rate of persistence (99.5%) versus 81.1% for those enrolled in emporium courses. The logistic regression models estimate that the former were nearly 12 times more likely to succeed than the latter after controlling for background characteristics. Access to the corequisite remedial mathematics courses was determined, to a degree, by socio-historical factors, particularly, opportunities to learn advanced high school mathematics (pre-calculus, calculus, or statistics).

This chapter will also demonstrate that success in remedial mathematics is closely related to persistence. All of the participants who failed to persist in their fall remedial mathematics courses were unable to complete a college-level mathematics course by the end of the academic year (spring). Again, there were differences by course type; all but one of the 316 participants who did not persist in the fall were enrolled in emporium remedial mathematics courses.

The results (i.e., estimated odds in the quantitative models) are consistent with the thesis that the racialized experiences of African American high school students' in K-12 mathematics classrooms affects their persistence and success in mathematics in the university setting. Although, African American and minority status were not statistical predictors of persistence or success, the participants' perceptions of their remedial mathematics teachers were. I hypothesized that the relationship between the participants' perceptions of their remedial mathematics teacher, persistence and success was due to a number of institutional, classroom and intrapersonal factors that differentially impacted minority students who were grossly overrepresented in the emporium courses, when compared with the university population (51.2% African American versus 12.9% university-wide and 80.3% minority versus 43% university-wide; OIRPA) and with the corequisite population (51.2% African American versus 37.2% in corequisite courses, and 80.3% minority versus 60.6% in corequisite courses). This hypothesis is explored qualitatively in Chapter 5.

In the remainder of the chapter, I first present descriptive statistics of the participants, which point to possible explanations of participants' persistence and success. Then, I present the inferential statistics, specifically, logistic regression models that help to explain the factors that predict remedial mathematics students' persistence and success.

Descriptive Statistics

The corequisite and emporium models. Remedial mathematics students enrolled in corequisite courses were more likely to persist and succeed than those enrolled in emporium courses. While over 92% of the study participants completed their remedial mathematics requirements in their first semester (i.e., they persisted), there were discrepancies in persistence rates based on whether the participants were in an emporium remedial mathematics class or a corequisite remedial mathematics class. Departmental data indicated that only one participant enrolled in a corequisite remedial mathematics course, out of the 189 total, did not persist (.5%). In contrast, roughly 18.9% of the participants in the emporium courses did not persist (24/127). Also, 88% of participants enrolled in corequisite courses completed their subsequent college-level mathematics course within the academic year, while only 39% of participants enrolled in the emporium courses were able to do so.

The higher rates of persistence and success for corequisite students was not surprising as prior studies have shown similar outcomes for the corequisite model (Palmer, 2016; Tennessee Board of Regents, 2016). For this study, the higher rates of persistence and success among corequisite students could partially be explained by institutional factors and non-random sorting of students to the two types of remedial mathematics courses. In particular, amongst those students who do not place into college-level mathematics on the placement tests at this university, only the top 50% place into the corequisite courses. So, according to the institution, corequisite students have a stronger understanding of mathematics and will be more likely to complete their remedial and college level mathematics requirements than emporium students. In other words, the superior persistence outcomes for corequisite courses could be due to non-random sorting of students to the remedial mathematics course models, the emporium model itself (e.g., better instruction and supports), or some combination thereof.

Irrespective of student sorting, it may be that the corequisite model works better for remedial mathematics students than the emporium model. Several institutional, classroom and intrapersonal factors suggest that and also, why this may be the case. In particular, if students place into corequisite remedial mathematics courses that naturally transition to a college-level mathematics course with the same peers and instructor, their odds of persistence and success may be better. Also, the corequisite courses are structured like other college-level mathematics courses at the university. They are held in mathematics classrooms in the mathematics building, and mathematics instructors take on traditional instructional roles. Because of these university and classroom environmental factors, the students enrolled in corequisite courses may not perceive their remedial mathematics courses as being very different from other college-level mathematics courses, whereas the same may not hold for those in emporium courses. With this in mind, the corequisite model may support comparatively more positive perceptions of social and academic integration, self-efficacy and perceptions of their remedial mathematics teachers, mathematics class and institution.

In contrast, emporium students who do not test out by the 5-week placement test re-take are automatically denied access to college-level mathematics for an entire semester. In comparison to corequisite students, emporium students are physically isolated from peers who are enrolled in college-level mathematics classes, as the emporium courses take place in a computer learning lab that is not located in the mathematics building. Further, the emporium instructor serves as a resource or facilitator but does not take on the traditional role of a teacher. As such, there is no whole class instruction at all. In an emporium classroom, students work independently on their assigned computer modules on their computers and the instructor is available to answer individual questions. Unless these students test out of the emporium remedial mathematics courses, they are entirely excluded from a typical college mathematics experience. Because students in remedial mathematics courses are highly motivated by affective, social and academic supports (Figure 18), it seems to make sense that those enrolled in corequisite courses would be more successful than those enrolled in emporium courses. Remedial mathematics students are more likely to find such supports in the group-taught, corequisite model than in the computer-based, emporium model. This possibility is also examined qualitatively in Chapter 5.

Personal goals and motivations. Overall, the participants in both emporium and corequisite courses reported being highly motivated to persist by both intrinsic and extrinsic motivators such as their desire for their education and work ethic, as well as affective, social and academic supports (RQ 1a; figure 17). The two highest-rated motivation items pertained to intrinsic motivators: the participants' *desire for their* *education* (μ =4.714, *s.d.*=.559) and their *work ethic* (μ =4.651, *s.d.*=.622). (As noted in Chapter 3, the motivation items were rated on a 5-point scale of importance with 1 = "Not at all" (1) to 5 = "Extremely important"). This result is consistent with Martin's (2000) finding that successful African American high school students were, "motivated by an inner drive and self-determination to succeed" (p. 183).

In addition to being highly motivated by intrinsic factors, the participants in both the emporium and corequisite courses were highly motivated by extrinsic factors such as *job guarantee* (μ = 4.459, *s.d.*=.886) and the *instructional support of their teacher* (μ = 4.210, *s.d.*=.818). Participants also rated highly affective supports, such as *the emotional support of family members* (μ = 4.009, *s.d.*=1.068), *professional relationships* (μ = 4.010, *s.d.*=.956), and *classroom experiences* (μ = 4.003, *s.d.*=.883), indicating that they were also very important motivators. This finding aligns with Tinto's (1975, 1987, 1993, 2007) results on the importance of academic and social integration to college persistence**.**

FIGURE 17: MOTIVATIONS: DESCRIPTIVE STATISTICS OF THE ANALYTICAL SAMPLE

	N	Mean	Std. Deviation
Desire for education	315	4.7143	.55947
Work ethic	315	4.6508	.62227
Job guarantee	314	4.4586	.88647
Instructional support from teacher	315	4.2095	.81813
Math grades	315	4.1619	.94219
Financial aid	316	4.0981	1.17373
Early professional mentoring	314	4.0669	.99455
Community and family relationships	315	4.0095	.95599
Emotional support of family	316	4.0095	1.06752
General class experiences	315	4.0032	.88331
Mentor access	315	3.9873	1.00627
Math class experiences	314	3.7070	1.04689
Emotional support from math teacher	314	3.5637	1.12085
Emotional support from peers	315	3.3429	1.17697
Instructional support from peers	314	3.1752	1.05650
Racial/ethnic identity	315	3.0159	1.59709
Teacher's perceptions of career goals	314	2.8854	1.28877
Friend's perceptions of career goals	314	2.7197	1.30045
Peer's perceptions of career goals	316	2.2057	1.22102
Valid N (listwise)	305		

As indicated, there were differences between persisters and non-persisters. In particular, the non-persisters were more likely than persisters to express a desire for career and classroom resources that supported their academic and career goals as well as their racial/ethnic identities. As shown in Figure 18, there were significant mean differences between persisters and non-persisters on the motivation items: (1) the emotional support from family and their remedial mathematics teacher, (2) early access to mentors and professional relationships with community and/or family members, (3) general and mathematics classroom experiences, (4) their math teachers' and peers' perceptions of their career choice, (5) their math grades and job guarantee, and (6) their racial/ethnic identities.

FIGURE 18: MOTIVATIONS: DESCRIPTIVE STATISTICS, GROUP COMPARISONS

Item	Persisters (μ, *s.d.*)	Non-Persisters (μ, s.d.)	Mann-Whitney U Test (*U*, *p*)
Emotional support (family)	3.961, 1.078	4.440, .821	2642.0, .016
Emotional support (teacher)	3.516, 1.125	4.080. .954	2531.5, .010
Mentor access	3.948, 1.006	4.600, .577	2527.5, .008
Perceptions of career choice (peers')	2.155, 1.189	2.880, 1.394	2707.0, .027
Perceptions of career choice (math teachers')	2.834, 1.278	3.400, 1.384	2599.5, .017
Math grades	4.128, .953	4.560, .712	2681.5, .020
Job guarantee	4.429, .907	4.800, .500	2821.0, .032
Professional relationships	3.969, .968	4.320, .945	2565.5, .010
Class experiences (general)	3.979, .872	4.440, .712	2794.0, .043
Class experiences (math)	3.661, 1.049	4.160, .898	2514.5, .009
Racial/Ethnic identity	2.930, 1.597	4.120, 1.092	2285.5, .002

Beliefs about math abilities and motivation to learn math. Overall, the participants tended to report low self-efficacy in their mathematics abilities, even when they said they had positive secondary mathematics experiences. That is, while the participants generally agreed that they had had 'positive secondary math experiences' (μ=3.324, *s.d.*=1.347), they generally disagreed with the items, 'I am a top student,' 'I am good at math,' and 'I want more math classes,' (μ=2.696, *s.d.*=1.079; 2.931, *s.d.*=1.147 and 2.690, *s.d.*=1.441, respectively). They also generally agreed with the item, 'I am challenged by my math class' (μ=3.817, *s.d.*=1.080). In terms of differences between persisters and non-persisters, there were significant mean differences (U=2004.5, p<.01) on their responses to the item 'I am a top student' (μ=2.760, *s.d.*=1.044 for persisters and μ=1.957, *s.d.*=1.296 for non-persisters; RQ1b).

It is not surprising that students in remedial mathematics courses would report low self-efficacy in mathematics, even if they reported having had positive high school mathematics experiences. Through being placed into remedial mathematics, the participants were informed by the university that they were not performing at an acceptable level in mathematics, and this likely negatively impacted their mathematics self-efficacy.

It is also not surprising that participants who struggled to persist in their remedial mathematics classes in the emporium courses would have lower self-efficacy than their more successful peers in the corequisite courses. This finding aligns with Marsh and Martin's (2011) work on the direct relationship between academic performance and self-concept.

Perceptions of school climate, peers and teachers. Overall, the participants generally cited having positive perceptions of their university's environment, peers, and mathematics teachers (RQ 1c). They generally agreed with the statements, 'I have positive relationships with my peers at the university' (μ= 3.712, *s.d.*=1.816), 'I have a sense of belonging at the university' (μ= 3.974, *s.d.*=1.003), and 'I have math supports outside of [their remedial] mathematics class' (μ= 3.971, *s.d.*=1.178). In addition, they were more likely to agree than disagree with the statements 'My math teacher is welcoming' (μ= 4.170, *s.d.*=.952), 'My math teacher expects me to succeed in math' (μ= 4.223, *s.d.*=.887), 'My math teacher believes I can succeed in math' (μ= 4.105, *s.d.*=1.011), and 'My math teacher supports my conceptual understanding in math class' (μ= 4.016, *s.d.*=.968). The participants were also more likely to agree than disagree with 'My classmates and I have similar beliefs about the university,' 'My classmates and I have similar beliefs about math class,' 'My classmates and I have similar beliefs about mathematics,' and 'My classmates and I have similar beliefs about the importance of math success' (μ=3.6, *s.d.*=.938;μ=3.536, *s.d.*=.910; μ=3.513, *s.d.*=.932 and μ=3.397, *s.d.*=1.167, respectively). However, they were typically neutral in their responses to the item 'My friends would say I am good at math' (μ=3.180, *s.d.*=1.272).

While remedial students generally had favorable views, the non-persisters had more negative perceptions of their mathematics classroom environment and their remedial mathematics teacher than persisters (RQ 1c). Given the previous discussion on their self-efficacy, the latter finding is not surprising. As seen in Figure 19, non-persisters had more negative perceptions of their mathematics class and math teachers than persisters, as their mean scores were significantly lower than persisters.

FIGURE 19: PERCEPTIONS OF SCHOOL CLIMATE, PEERS AND TEACHER, GROUP COMPARISONS

Item	Persisters (μ, *s.d.*)	Non-Persisters (μ, s.d.)	Mann-Whitney U Test (*U, p*)
I like math class	3.477, 1.239	2.783, 1.536	2411.0, .033
My math teacher is welcoming	4.237, .865	3.348, 1.496	2153.5, .004
My math teacher supports my conceptual understand	4.078, .876	3.261, 1.602	2414.0, .029

Enrollment in emporium courses and minority status were associated with the participants' perceptions of receiving differential treatment in mathematics-related contexts. While the participants generally disagreed that they had experienced differential treatment in mathematics-related contexts due to their race or ethnicity ($\mu=1.724$, $s.d.=1.198$), this differed based on their remedial course assignment. Specifically, significant mean differences were identified based up enrollment in an emporium ($\mu=2.041$, $s.d.=1.287$) versus corequisite remedial mathematics course ($\mu=1.514$, $s.d.=1.099$) and the participants' racial/ethnic identity (Mann-Whitney $U=8379.5$, $p<.01$ and Kruskal-Wallis $H=19.836$, $df=3$, $p<.01$, respectively; Figures 20 and 21). Interestingly, there were no significant mean differences between persisters and non-persisters in terms of perceptions of differential treatment in mathematics-related contexts (Mann-Whitney $U=3135.0$, $p=.771$). Latinx and Black students were more likely to perceive that they experienced differential treatment in mathematics related contexts, as indicated by their mean item response scores (Figure 22).

FIGURE 20: PERCEPTIONS OF DIFFERENTIAL TREATMENT: MEAN RANK COMPARISON BY COURSE TYPE

	Course	N	Mean Rank	Sum of Ranks
Ihavebeentreateddifferentlyinmathduetomyraceethnicity	Emporium	121	174.75	21144.50
	Co-requisite	183	137.79	25215.50
	Total	304		

FIGURE 21: PERCEPTION OF DIFFERENTIAL TREATMENT: MEAN RANK COMPARISON BY RACE/ETHNICITY

	RaceEthnCitzMulti	N	Mean Rank
Ihavebeentreateddifferentlyinmathduetomyraceethnicity	White	97	127.60
	Black/African American	127	166.60
	Latinx	50	168.51
	Asian, Indigenous, Bi or Multi-Racial	29	141.21
	Total	303	

FIGURE 22: PERCEPTIONS OF DIFFERENTIAL TREATMENT BY RACIAL/ETHNIC IDENTITY

Ihavebeentreateddifferentlyinmathduetomyraceethnicity

	N	Mean	Std. Deviation
White	97	1.3299	.85051
Black	127	1.9685	1.32699
Latinx	50	1.9800	1.31692
Asian, Indigenous, Bi or Multi-Racial	29	1.5517	1.12078
Total	303	1.7261	1.20466

The fundamental importance of mathematics. Overall, the participants reported that their success in mathematics was important and that they engaged in a variety of academic behaviors linked to student success in remedial mathematics classes (Zienteck et al., 2014). In particular, they were more likely to agree than disagree with the statements, ‘Math success is important for attaining my career goals’ (μ=3.944, *s.d.*=1.170) and ‘My success in math is important to me,’ (μ=4.279, *s.d.*=.938). However, they were neutral about applications of formal mathematics in their daily lives (RQ 1d). They were also more likely to agree than disagree that: 'Attending my math class is a priority' (μ=4.330, *s.d*.=.939); 'I always complete my math homework' (μ=4.332, *s.d*.=.874); 'If I have questions about math, I make a point to seek answers by meeting with my teacher/TA, tutors, or classmates' (μ=3.982, *s.d*.=1.002), and 'I work through challenges in my mathematics classrooms and do not give up' (μ= 3.867, *s.d*.=1.079). Interestingly, non-persisters were more likely than persisters to perceive mathematics as important to their career goals and their families. There were significant mean differences between persisters and non-persisters on the item 'Math is related to my career goals' (μ=3.439, *s.d*.=1.365 versus μ=3.869, *s.d.*=1.517; U=2322.0, p<.05) and 'Math success is important to my family' (μ=3.855, *s.d*.=1.201 versus μ=4.478, *s.d*.=.730; U=2367.5, p<.05).

Explaining Persistence and Success: Inferential Statistics

This section turns to the regression models of remedial mathematics students' persistence and success. The descriptive statistics presented in the previous section, along with exploratory factor analysis and correlation analysis described in Chapter 3, provided insight into what might drive the participants' persistence. To be clear, I examined bivariate correlations between the analytic variables and the outcomes of interest. In doing so, I identified five intrapersonal factors: the participants' beliefs about their mathematics abilities and motivation to learn mathematics, their perceptions of their remedial mathematics teachers, the perceptions of others, academic integration and social integration significantly correlated with the participants' persistence and success. Gender, age, last high school mathematics course, African American identity, and the primary parent/guardian's highest level of education were also significantly correlated with, and identified as potential contributors to, persistence and success. These bivariate correlations did not explain how the various predictors interact to co-produce the outcomes of persistence and success. For that, statistical modeling – or inferential statistics – was necessary, but these preliminary findings supported the selection of the variables included in the final regression models.

Modeling persistence. The logistic regression model discussed in this section answers the research questions about the factors that were predictive of remedial mathematics students' persistence. It allows for comparisons between individual participant characteristics and their persistence outcomes. In this section, I first discuss the logistic regression findings for the entire analytical sample (Figures 23, 24 & 25). Given the significant differences in persistence based on enrollment in emporium or corequisite remedial mathematics courses, I then discuss logistic regression findings for the emporium group only (Figures 26, 27 & 28).

FIGURE 23: FINAL PERSISTENCE LOGISTIC REGRESSION MODEL: FULL SAMPLE, BLOCK 1

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender(1)	1.330	.489	7.385	1	.007	3.779
	AAFlag	-.988	.478	4.276	1	.039	.373
	parentedlevel	1.405	.469	8.959	1	.003	4.077
	Constant	1.487	.477	9.717	1	.002	4.426

a. Variable(s) entered on step 1: Gender, AAFlag, parentedlevel.

FIGURE 24: FINAL PERSISTENCE LOGISTIC REGRESSION MODEL: FULL SAMPLE, BLOCK 2

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender(1)	1.143	.508	5.057	1	.025	3.137
	AAFlag	-.829	.498	2.774	1	.096	.436
	parentedlevel	1.501	.497	9.113	1	.003	4.487
	LastK12mathcourse	2.016	.587	11.780	1	.001	7.508
	Constant	.625	.533	1.378	1	.240	1.869

a. Variable(s) entered on step 1: LastK12mathcourse.

FIGURE 25: FINAL PERSISTENCE LOGISTIC REGRESSION MODEL: FULL SAMPLE, BLOCK 3

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender(1)	1.539	.611	6.343	1	.012	4.660
	AAFlag	-.497	.597	.692	1	.406	.608
	parentedlevel	1.455	.566	6.610	1	.010	4.286
	LastK12mathcourse	2.177	.693	9.877	1	.002	8.818
	Beliefs about math abilities and mtlmath	.298	.295	1.022	1	.312	1.347
	Motivation academic integration	-.193	.406	.227	1	.634	.824
	Motivation social integration	-.767	.573	1.796	1	.180	.464
	Motivation the perceptions of others	-.470	.384	1.501	1	.221	.625
	perceptions of teacher	.593	.275	4.662	1	.031	1.809
	Constant	.859	.613	1.968	1	.161	2.362

a. Variable(s) entered on step 1: Beliefs about math abilities and mtlmath, Motivation academic integration, Motivation social integration, Motivation the perceptions of others, perceptions of teacher.

Students' perceptions of their remedial mathematics teacher were significantly associated with persistence. For every one standard deviation increase in a participant's perceptions of their remedial mathematics teacher, the odds of persistence nearly doubled, when holding all other predictors constant. That is, above and beyond race and other demographic characteristics, the teacher-student relationship appears to be salient.

The educational background of the remedial math students and their parents also explains their persistence — rigorous mathematics course-taking in high school advantages students in remedial college mathematics. Participants who reported taking more advanced mathematics courses in high school (pre-calculus, calculus or statistics) were nearly nine times more likely to persist than those who did not. Also, participants who had a primary parent/guardian with at least some college education were about 4.3 times more likely to persist than those who had a primary parent/guardian with no college education, holding all other predictors constant. For the full sample (Figure 25), the odds of persistence were roughly 4.7 times greater for females than their male counterparts, when holding all other predictors constant.

Student race also appears to matter to persistence in remedial mathematics, albeit indirectly. In block 1 of the full sample logistic regression (Figure 23), which controls for students' time-invariant demographic predictors, being African American was a statistically significant predictor of persistence (Wald = 4.276, *df* = 1, *p* = .039), with the odds ratio indicating African American students were 2.7 times more likely not to persist than their peers. After adding the predictor *last K12 mathematics course* to the model in block 2 of the full sample (Figure 24), African American identity was no longer a statistically significant predictor of persistence (Wald = 2.774, *df* =1, *p* =.096). These results indicate there is a correlation between advanced high school mathematics course taking and placement into corequisite remedial mathematics courses at this university, and they suggest that African American students' racialized experiences in K-12 mathematics affect their persistence outcomes in a university setting.

The full logistic model of persistence was statistically significant ($X^2 = 62.164, df = 9, p < .01$). A good model fit was evidenced by a -2 Log Likelihood value (94. 063) greater than the critical chi-squared value (9.49), by non-statistically significant results on the Hosmer-Lemeshow test, $X^2(n = 293) = 4.868,\ df = 8, p = .772,$ and by the effect size indices, which indicated small to medium effects (Cox and Snell R^2 = .191; Nagelkerke R^2= .463; Cohen, 1988).

FIGURE 26: FINAL PERSISTENCE LOGISTIC REGRESSION MODEL: EMPORIUM GROUP, BLOCK 1

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender	1.384	.523	6.988	1	.008	3.989
	parentedlevel	1.147	.515	4.950	1	.026	3.149
	AAFlag	-.661	.516	1.640	1	.200	.517
	Constant	.463	.540	.735	1	.391	1.589

a. Variable(s) entered on step 1: Gender, parentedlevel, AAFlag.

FIGURE 27: FINAL PERSISTENCE LOGISTIC REGRESSION MODEL: EMPORIUM GROUP, BLOCK 2

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender	1.208	.545	4.903	1	.027	3.346
	parentedlevel	1.136	.542	4.394	1	.036	3.113
	AAFlag	-.658	.539	1.491	1	.222	.518
	LastK12mathcourse	1.655	.617	7.206	1	.007	5.233
	Constant	-.042	.586	.005	1	.943	.959

a. Variable(s) entered on step 1: LastK12mathcourse.

FIGURE 28: FINAL PERSISTENCE LOGISTIC REGRESSION MODEL: EMPORIUM GROUP, BLOCK 3

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender	1.361	.659	4.269	1	.039	3.899
	parentedlevel	1.184	.620	3.643	1	.056	3.266
	AAFlag	-.064	.657	.009	1	.923	.938
	LastK12mathcourse	1.786	.749	5.689	1	.017	5.968
	Beliefs about math abilities and mtlmath	.001	.333	.000	1	.998	1.001
	Motivation the perceptions of others	-.158	.461	.118	1	.732	.854
	Motivation academic integration	-.743	.512	2.105	1	.147	.476
	Motivation social integration	-.515	.752	.470	1	.493	.597
	perceptions of teacher	.676	.311	4.738	1	.030	1.967
	Constant	.011	.695	.000	1	.988	1.011

a. Variable(s) entered on step 1: Beliefs about math abilities and mtlmath, Motivation the perceptions of others, Motivation academic integration, Motivation social integration, perceptions of teacher.

I reran the persistence model for just the emporium students, given that all but one of the co-requisite students persisted. As a comparison between Figures 23-25 and Figures 26-28 show, the models of the emporium group's persistence were generally consistent with the persistence models for the full sample. For the emporium group's persistence model, females were still four times more likely to persist than their male peers, when holding all other predictors constant. Participants who took advanced mathematics courses in high school (pre-calculus, calculus or statistics) were roughly 6 times more likely to persist than those who did not, and, like the full sample finding, for every 1 standard deviation increase in a participant's perceptions of their remedial mathematics teacher, the odds of persistence nearly doubled, when holding all other predictors constant. While the primary parent/guardian(s) level of education was found to be a significant predictor of persistence in the second block of the logistic regression for the emporium group (Wald = 4.394, *df* = 1, *p* = .036; Figure 27), some of the variance in persistence was better explained by beliefs factors, particularly, the participants' perceptions of their remedial mathematics teachers. When these factors were added to the third block of the model, the primary parent/guardian(s) level of education was no longer found to be a significant predictor of persistence (Wald = 3.643, *df* = 1, *p* = .056; Figure 29), but their perceptions of their remedial mathematics teacher was a significant predictor of their persistence (Wald = 4.738, *df* = 1, *p* = .030).

As was the case for the full sample persistence logistic regression, the model fit the emporium data well. The overall regression was statistically significant ($X^2 = 41.961, df = 9, p < .01$). Good model fit was evidenced by a -2 Log Likelihood value (71. 560) greater than the critical chi-squared value (9.49), non-statistically significant results on the Hosmer-Lemeshow test, $X^2(n = 118) = 6.623,\ df = 8, p = .578$, and the effect size indices, which indicated small to medium effects (Cox and Snell R^2 = .299; Nagelkerke R^2= .484; Cohen, 1988). The model correctly predicted participants with 85.6% accuracy; 45.5% of those who did not persist and 94.8% of those who did. It is worth noting that the predictor 'Current course' was not in these final models. During the logistic regression analysis, I found that the relationship between 'Current course' and participants' persistence made it difficult for the logistic regression model to converge on a solution. This modeling issue stemmed from the lack of variance in the persistence rates of the corequisite participants (99.5% persisted).

Modeling success. The logistic regression models indicate that participants' success was closely related to their persistence. As shown in Figure 29, participants enrolled in a corequisite course were nearly 12 times more likely to succeed than their peers enrolled in the emporium courses. Gender remained a significant contributor to success, as females were three times more likely to succeed than males when holding all other predictors constant. While playing a less significant role, beliefs also contributed to the participants' success. The odds of success were 1.4 times higher for every one standard deviation increase in a participant's perceptions of their remedial mathematics teacher (p=.059).

An unexpected finding was that, although the participants' choice of undergraduate major was not a predictor of success ($p=.059$) there appeared to be some correlation between the two (r=-.147, p<.01). When looking further into the relationship between choice of major and mathematics success, I discovered that non-STEM and Business majors enrolled in remedial mathematics were more likely to succeed in their subsequent college-level mathematics course than their peers who were STEM majors. While this could be due to content differences in the college level mathematics course, such as Algebra versus Pre-Calculus or Calculus content, I suspect institutional, and classroom factors play a role. I investigate this hypothesis qualitatively in Chapter 5.

FIGURE 29: FINAL SUCCESS LOGISTIC REGRESSION MODEL: FULL SAMPLE

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender	1.125	.323	12.155	1	.000	3.081
	CollOfMaj	-.040	.095	.178	1	.673	.961
	Course	2.475	.343	52.157	1	.000	11.885
	AAFlag	-.322	.314	1.056	1	.304	.724
	LastK12mathcourse	.199	.316	.396	1	.529	1.220
	Beliefs about math abilities and mtlmath	-.013	.176	.006	1	.940	.987
	perceptions of teacher	.320	.169	3.557	1	.059	1.377
	Constant	-.980	.464	4.458	1	.035	.375

a. Variable(s) entered on step 1: Beliefs about math abilities and mtlmath, perceptions of teacher.

As with the persistence models, this final success model fit the success data well. The overall regression was statistically significant ($X^2 = 101.699, df = 7, p < .01$). Good model fit was evidenced by a -2 Log Likelihood value (266) greater than the critical chi-squared value (11.07)the non-statistically significant results on the Hosmer-Lemeshow test, $X^2(n = 316) = 7.520,\ df = 8, p = .482$, and the effect size indices, which indicated small to medium effects (Cox and Snell R^2 = .293; Nagelkerke R^2= .410; Cohen, 1988). The model correctly predicted participants with 78.5% accuracy; 62.8% of those who did not succeed and 85.9% of those who did.

Due to the significant differences in the success rates of those enrolled in corequisite versus the emporium courses, it was essential to run a separate regression analysis on the latter group (Figure 30). Gender had the same impact on the emporium group's success, as females were three times more likely to succeed than males from these courses when holding all other predictors constant (*p*<.01). Also, for every one standard deviation increase in the emporium group's perceptions of their teacher, the odds of success increased by a factor of 1.5 (*p*=.05). First generation status also impacted the emporium group’s success. Although not statistically significant (*p*=.053), students enrolled in the emporium courses whose parents had at least some college education were 2.5 times more likely to succeed than students whose parents had no college education. This overall regression was statistically significant ($X^2 = 22.398, df = 4, p < .01$). Good model fit was evidenced by a -2 Log Likelihood value (147.88) greater than the critical chi-squared value (7.81), non-statistically significant results on the Hosmer-Lemeshow test, $X^2(n = 128) = 5.774,\ df = 8, p = .673$, and the effect size indices, which indicated small effects (Cox and Snell R^2 = .162; Nagelkerke R^2= .219; Cohen, 1988). The model correctly predicted participants with 70.9% accuracy; 83.1% of those who did not succeed and 52% of those who did.

FIGURE 30: FINAL SUCCESS LOGISTIC REGRESSION MODEL: EMPORIUM GROUP

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Age	-1.080	.575	3.527	1	.060	.340
	Gender	1.170	.418	7.828	1	.005	3.224
	parentedlevel	.914	.473	3.737	1	.053	2.494
	perceptions of teacher	.429	.219	3.842	1	.050	1.535
	Constant	-1.616	.525	9.488	1	.002	.199

a. Variable(s) entered on step 1: perceptions of teacher.

Discussion

Through this quantitative analysis, I found that the participants' high rates of persistence and success could partially be explained by enrollment in corequisite versus emporium remedial mathematics courses. This finding was partially due to the institution's non-randomized sorting of students into the emporium and corequisite remedial mathematics courses based upon institutional markers (placement test scores) which were influenced by sociohistorical factors (primarily access to advanced high school mathematics courses). Minorities, first-generation college students, and those with less exposure to advanced mathematics courses (pre-calculus, calculus or statistics) in high school were more likely to be enrolled in the emporium remedial mathematics courses than the corequisite courses. Thus, the emporium courses contained more participants with characteristics of students who have historically had less opportunity to learn higher level mathematics, are underrepresented in STEM and are at higher risk of college drop-out (U.S. Department of Education for Civil Rights, 2014). While age, gender, African American identity, first-generation status, and high school mathematics course-taking all contributed to persistence and success to some degree, gender was a stronger predictor of persistence and success than minority or first-generation status, and high school mathematics course-taking was the most influential demographic predictor of persistence, when I excluded corequisite enrollment from the regression model. Davidson and Petrosko have previously reported the significance of gender on persistence and success in remedial mathematics (2015), and Mireles et al. (2014) also found, “no statistically significant effects of ethnicity on course withdrawal” (p. 29).

The participants’ high degree of intrinsic and extrinsic motivation, their more positive beliefs about the university climate, their peers and their remedial mathematics teachers, their views that success in mathematics was important, and their engagement in productive academic behaviors partially explained their high rates of persistence (Martin, 2000; Zienteck et al., 2014; Table 2).

My findings on the positive perceptions of peers and the university climate contradict Martin's qualitative findings (2000), as does my discovery that the participants' tended to disagree that they experienced differential treatment in mathematics related contexts due to their race/ethnic identity. However, my population and sample were different from Martin's (2000), my data collection methods were different (survey versus in-depth interviews), and when disaggregated, there were significantly higher Latinx and African American participants who reported their perceptions of differential treatment in mathematics related contexts. My results on the participants' more positive perceptions of their peers and the university climate align with Tinto's work on the relationship between perceptions of school climate and undergraduate persistence (1975, 1987, 1993, and 2007).

Two intrapersonal factors, the participants' beliefs about their mathematics abilities, their motivation to learn math, and their perceptions of their remedial mathematics teachers were found to impact the participants' persistence and success positively. These positive relationships align with Martin's qualitative results (2000). Of the two intrapersonal predictors, the most influential was the participants' perceptions of their mathematics teacher. Since the participants in the emporium model were significantly less likely to persist, I hypothesized that institutional or classroom factors were negatively influencing these participants' perceptions of their mathematics abilities and their remedial mathematics teachers and in turn, their persistence and success.

Three motivation factors: social integration, academic integration and the perceptions of others, were inversely related to persistence. The inverse relationship between persistence and the motivation factor the perceptions of others was consistent with Martin's (2000) finding that successful African American mathematics students were not motivated by the perceptions of their peers; instead, they actively sought out opportunities to distinguish themselves from their peers, whom they perceived to be less successful. On the other hand, the inverse relationship between persistence and the motivation factors social integration and academic integration were concerning. As previously mentioned, the participants in this study were highly motivated by their ability to integrate both academically and socially, and there is substantive research indicating academic and social integration are crucial to undergraduate retention and persistence (Tinto, 1975, 1987, 1993, & 2007, and others). Thus, I also hypothesized that institutional and classroom factors were negatively influencing emporium students' perceptions of academic and social integration and their academic and social experiences and subsequently, their persistence and success.

TABLE 2: SUMMARY OF QUANTITATIVE FINDINGS

Research Question	Findings
How do mathematics experiences and intrapersonal forces relate to the persistence and success of undergraduates enrolled in remedial mathematics classes?	More positive secondary math experiences. Positive beliefs (about math abilities) and perceptions (of the teacher) were positively correlated with persistence and success. Perceptions of teacher impacted persistence and success. Motivations (by perceptions of self and others, academic integration and social integration) were negatively correlated with persistence. With current math course (emporium or corequisite) removed from the regression model, gender (female), highest level of education of primary parent/guardian (some college), last high school math course (pre-calc., calc., or statistics), minority status and perceptions of the teacher were significant predictors of persistence. Gender and corequisite enrollment were significant predictors of success.
What personal goals and motivations are important to undergraduates enrolled in remedial mathematics courses?	Highly motivated by intrinsic and extrinsic factors, including items that pertained to work ethic, desire for education, affective, social and academic supports.
What do they believe about mathematics and their mathematics abilities?	Lower self-efficacy in college mathematics and little interest in pursuing more mathematics.
What are their perceptions of the school climate and mathematics teachers?	More positive. Somewhat disagreed or strongly disagreed that they were treated differently in math due to their race/ethnicity. Students of color and students in the emporium courses tended to somewhat disagree, while White students and corequisite students tended to strongly disagree.
What are their perceptions of their peers?	Agreed that their classmates held similar beliefs about school, their math class, mathematics, and math success but neutral about whether their peers would say they were good at math.
What motivates their learning of mathematics?	Success in their mathematics courses was important to achieving their career goals; engaged in productive academic behaviors to ensure their success.

Given these findings, I posited that the corequisite model might merely work better for remedial students by supporting more positive beliefs and perceptions overall. I also asserted that students in the emporium courses faced institutional and classroom barriers that result in more negative perceptions and beliefs, ultimately reducing their ability to persist and succeed. Given the fact that the emporium students were 51.2% African American and 80.3% minority, this hypothesis would confirm that emporium course placement is racialized. To inform my understanding of institutional and classroom factors that may negatively impact the beliefs and perceptions of the participants enrolled in emporium remedial mathematics courses, specifically their ability to integrate socially and academically and their perceptions of their remedial mathematics teachers, I used the following additional research questions to motivate the qualitative data collection methods and procedures:

f. Why do the participants' perceptions of teacher scores help us predict their persistence and success?

g. In what ways do the participants' beliefs (about their mathematics abilities), perceptions (of their teacher) and motivations (perceptions of others, academic and social integration) inform our understanding of barriers and opportunities that impact the persistence and success of undergraduates enrolled in remedial mathematics courses at four-year universities?

As discussed in Chapter 3, the quantitative findings informed the selection of five *perceptions of teacher* cases which were used for the qualitative data collection and analysis.

After selecting and interviewing the five participants, I coded their interview transcripts thematically, using the five intrapersonal factors significantly correlated with persistence as the selected themes: beliefs about mathematics abilities and motivation to learn mathematics ($r = .116, p < .05$), perceptions of the teacher ($r = .169, p < .01$), the perceptions of others ($r = -.143, p < .05$), academic integration ($r = -.163, p < .01$) and social integration ($r = -.177, p < .01$). After thematically coding each participant's interview data, I integrated the qualitative and quantitative findings in a joint display which was used to conduct the cross-case analysis and extrapolate the broader findings/themes. In Chapter 5, I present my cross-case qualitative findings. In Chapter 6, I summarize the implications of the integrated quantitative and qualitative results, report on the limitations of the study and identify goals for future research.

CHAPTER 5: Qualitative Persistence Findings

In this chapter, I present my qualitative findings. I begin this chapter by briefly recalling the quantitative findings and conclusions that informed and justified the qualitative data collection and analysis that are the focus of this chapter. I then introduce the five case study participants and present three assertions that resulted from the cross-case analysis. To support these assertions, I draw upon the thematically coded qualitative data that was collected from my five perceptions of teacher cases and aligned with the factors significantly correlated with the participants' persistence. Recall from Chapter 4, that these factors were: their *perceptions of their remedial mathematics teacher*, their *beliefs about their mathematics abilities and motivation to learn mathematics*, and *their perceptions of others, academic integration and social integration.*

Review of Quantitative Findings

The quantitative analysis showed that the study participants' high rates of persistence were partially explained by the fact that the they were highly motivated by intrinsic motivators such as their work ethic and desire to obtain post-secondary degrees – motivators previously identified among successful African American high school mathematics students (Martin, 2000). The quantitative analysis also showed that the participants were highly motivated by extrinsic motivators, including affective, social and academic supports. They generally reported having positive perceptions of the university, their remedial mathematics classes, and their remedial mathematics teachers and their peers. They also self-reported high engagement in academic behaviors that attributed to success in remedial mathematics – this also is consistent with the literature (Tinto, 1975, 1987, 1993, and 2007; Zeinteck, 2014). However, the quantitative analysis indicated that

African American and minority students had differential experiences in remedial mathematics from the White students which was clearly related to their over-representation in emporium courses.

In the aggregate, participants' high rates of persistence could partially be explained by the assignment of a large number of them to corequisite courses instead of emporium courses as they were more successful as a group in the former course type. At the same time, minority students, first-generation college students, and those with less exposure to advanced mathematics courses (e.g., pre-calculus, calculus or statistics) in high school were more likely to place in the emporium remedial mathematics courses than the corequisite courses. This racialized placement of students into emporium courses resulted in racialized outcomes. The university assigned students based upon institutional markers (i.e., placement test scores) which were influenced by sociohistorical factors related to access to advanced high school mathematics courses. The quantitative analysis indicated that placement into the emporium courses – instead of corequisite courses – tended to negatively impact the participants' experiences, beliefs and perceptions, reducing their likelihood of persistence and success. The participants' beliefs about their mathematics abilities, motivation to learn math, and their perceptions of their remedial mathematics teachers were each found to positively impact their persistence and success. The most influential of these intrapersonal factors was the participants' perceptions of their remedial mathematics teacher.

Since the participants in the emporium model were significantly less likely to persist than those in the corequisite model, I hypothesized that institutional or classroom factors were negatively influencing these participants' perceptions of their mathematics abilities and their remedial mathematics teachers. All of the three motivation factors - social integration, academic integration and the perceptions of others - were inversely related to persistence, despite participants' high degree of motivation for academic and social integration. Thus, I also hypothesized there were institutional or classroom barriers that limited the degree to which the participants in emporium courses were able to integrate with the campus community, both socially and academically. If such barriers did exist, it could help to explain the more negative beliefs and perceptions of the participants enrolled in the emporium courses. It also would help to explain their lower rates of persistence and success.

Finally, I hypothesized that the corequisite model works better than the emporium model for the majority of remedial students. My reasoning was that the corequisite model is similar to college-level mathematics classes, and it transitions into a college-level mathematics class after the five-week placement test re-take. However, in contrast, the emporium courses isolate students from a more representative college-level mathematics experience – that is, unless they are able to test out of the emporium course by the five-week placement test re-take. As the quantitative findings suggested, the remedial mathematics students in this study were highly motivated by affective, social, and academic supports, so I argued that it made sense that those enrolled in corequisite courses would be more likely to persist and succeed than those enrolled in emporium courses. In sum, students in remedial mathematics are more likely to find the supports they desire in a corequisite course than in a computer-based, emporium course.

In response to the quantitative findings, the following additional sub-questions emerged and motivated the qualitative data collection methods and procedures:

f. Why do the participants' perceptions of teacher scores help to predict their persistence and success?

g. In what ways do the participants' beliefs about their mathematics abilities, perceptions of their teacher, and motivations by the perceptions of others, academic and social integration inform our understanding of barriers and opportunities that impact the persistence and success of undergraduates enrolled in remedial mathematics courses at four-year universities?

To answer these qualitative research questions, I selected five participants using extreme case selection of perception of teacher cases as outlined in detail in Chapter 3. Recall that one mean perception of teacher case was selected as a referent alongside four extreme perception of teacher cases. Again, as the quantitative analysis demonstrated, there were no extreme positive perception of teacher cases. Since all perception of teacher extremes were negative extremes, I expected the findings for these four participants would be reflective of the skewed perception of teacher data. As outlined in Chapter 3, although the five-extreme perception of teacher cases were all African American students, they were diverse across gender, educational levels of parents, high school mathematics course-taking, major, persistence and success. Three participants were female and two were male. Three had parents/guardians who had no college education and two of them had parents/guardians with college educations. Three of them took an advanced mathematics course (Pre-calculus, Calculus or a Statistics) as their last high school mathematics class, but two of them did not.

Three participants were in emporium courses and two were in corequisite courses. Two participants were in the Academic Achievement Program, three were STEM majors, and two were non-STEM majors. Three of them persisted through their remedial mathematics classes, and two of them succeeded in their subsequent credit-bearing mathematics classes. Collectively, these participants will provide insight into the ways in which their unique backgrounds and mathematics socializations shaped their remedial mathematics experiences and mathematics identities, the role their identities played in shaping their perceptions of their remedial mathematics experiences and remedial mathematics course and teacher, and whether their mathematics identities were supported or challenged by their remedial mathematics experiences. What follows are brief narratives designed to introduce you to each of the five participants.

Introduction to the Case Study Participants

Ellie

Ellie Blue identified herself as an African female who was first generation American. She shared that her family lived locally, and that both of her parents were college-educated. Her mother worked in information systems for a local city police department, and her father worked in healthcare. Ellie took advanced IB mathematics courses that covered calculus and statistics material her senior year of high school. She reported that she studied for her first mathematics placement test at the university, but she initially placed into the emporium remedial mathematics class. Ellie attributed her poor performance on the placement test to the fact that she did not do well on timed tests, and she did not feel that her high school math courses prepared her for the content she saw on the exam. Ellie re-took the mathematics placement test in September and placed into College Algebra. However, her remedial mathematics professor informed her there weren't enough spots to move her to a College Algebra course that fit Ellie's schedule, telling her, "You can stay in this class and just do [College Algebra] work." Ellie claimed that "did not happen." She remained in and failed her emporium remedial mathematics course in the fall, but Ellie was placed into a credit-bearing College Algebra course in the spring because of her September mathematics placement test results.

Edna

Edna identified herself as a Black female who was a Business major. She attended a local high school where she took Statistics and Probability her senior year. Her parents did not have college educations, and Edna faced ongoing financial concerns which she attributed to her parents' lack of college education. Edna took the mathematics placement test three times the summer before her freshman year at the university, but she did not study for her placement tests. She claimed this was because she never had a dedicated time to study for them or take them. Instead, she was always "half cooking, half doing this." Edna also shared that she felt, "If I don't know it off the top of my head, then maybe I should relearn it." Like Ellie, Edna initially placed into an emporium remedial mathematics course, but she was able to complete her remedial mathematics requirements and move into College Algebra within the first five-weeks of the fall semester.

Marcus

Marcus identified himself as an African American male who transferred to the university as a sophomore from a local community college and was listed as a student in the Academic Achievement Program. His parents were both college educated, and his mother held a government job in IT security. While Marcus' college of major was listed as AAP in the departmental data, he was actually in the School of Letters and Sciences and undeclared. He shared that he intended to pursue an Information Systems degree, a major offered by the university’s Business School. Like Ellie, Marcus took IB Math Studies in high school. While he studied, “a little bit” for his mathematics placement test, Marcus placed into the emporium remedial mathematics class. He attributed his placement into remedial mathematics to not studying hard enough, not expecting the placement test to be as difficult as it was and having, “bad habits when it comes to math.”

Sparrow

Sparrow identified himself as a first-generation African American. He received most of his K-12 education in his home country (Ghana). Sparrow moved to the United States with his mother and younger siblings as a junior in high school, completing his last year and a half of his high school education locally. He also lived locally with his mother and siblings. Sparrow’s mother did not have a college education, so he was also a first-generation college student. Like Marcus, Sparrow was listed as belonging to the AAP in the departmental mathematics data, but he was actually a computer science major. He was also a sophomore who transferred from a local community college, where he had already taken two remedial mathematics courses:

> I did take, like, introductory math classes, and for the first one, I did fine, but then when I got the one I'm taking now…I got a D or something like that. So, I had to retake it again, and then, when I retook it, I, I think I didn't finish. So, that was like, automatic fail for me. So then, I transferred here.

Alana

Alana identified herself as a Black female. She grew up locally with her mother, who did not have a college education, and her siblings. Alana’s last high school mathematics was Algebra II with Trigonometry. Like Ellie and Edna, Alana did not study for the university’s mathematics placement exam, and she placed into the emporium remedial mathematics class. In her interview, she attributed her emporium course placement partly to being unsure how to properly study for the placement exam, and partly because, like Edna, she felt that if she didn't know the material without studying, she needed the content review she would get from the mathematics course she would be placed in:

> I didn't study, but I was planning on taking it again, and I started studying for it, but I was like, I just feel like this is a very large volume of information. I didn't really know how to study for it because I'm like, this is asking, like, a lot about math, like, over time, and my best score was, like, the trig section because that was a math that I just recently took. So, originally, I'm like, ‘Okay, well, maybe I'll just try to push through [the emporium course] like in a couple of weeks.' And I'm like, ‘Maybe I need the review.'

As an incoming freshman at the university, Alana was accepted into the university's Honor's College which typically represents the top 25% of admitted freshman each year. Like Edna’s living and learning program, Honor’s College students are usually housed on campus in living and learning communities. The Honor’s College offers specialized honors courses and programs, some of which culminate into capstones. The Honor’s College is academically focused, and students must maintain a GPA of 3.2 or above to remain active. Although Alana was identified as a non-STEM major in the College of Letters and Sciences in the mathematics departmental data, this was based her remedial mathematics course placement which restricted her from admittance into the Biology program, her intended major.

Initial Cross-Case Findings

As noted in Chapter 3, once each participant's full, thematically organized narratives were developed, I integrated the qualitative findings with the quantitative findings in a joint display. Figure 31 presents a simplified version of the joint display with the integrated data for each participant (rows) organized by theme (columns). The quantitative data, labeled in bold, indicates that the data for that participant falls outside of 1.5 standard deviations of the mean for the entire participant pool included in the quantitative analysis.

FIGURE 31: JOINT DISPLAY OF INTEGRATED DATA, BY THE CASE (ROW) AND THEME (COLUMN)

Case	**Major**	**Course**	**Persisted**	**Succeeded**	**Academic integration**	**Social integration**	**The perceptions of others**	**Beliefs about math abilities**	**Perceptions of the teacher**
					μ=0, s.d. =1	μ=0, s.d. =1	μ=0, s.d.= 1	μ=0, s.d. =.98399897	μ=0, s.d.=.98561076
					(r=-.163)	(r=-.177)	(r-.143)	(r=.116)	(r=.169)
					B=-.123	B=-.767	B=-.807	B=.391	B=.576
					Exp (B) =.884	Exp (B) =.465	Exp (B) =.446	Exp (B) =1.479	Exp (B) =1.779
					p=.772	p=.191	p=.062	p=.241	p=.041
Ellie Blue	Computer Science	Emporium initially	Passed into College Algebra at 5-week re-take. Remained in emporium and failed.	Passed College Algebra.	.54456 Negative	.57211 Negative	**-2.27123** Negative	.54368 Mixed	-1.19202 Mixed
Edna	Business	Emporium initially	Within the 1st 5-weeks in emporium	Passed Business Calculus	**-2.56777** Positive	**-2.44828** Positive	**-6.45052** Neutral	-0.7795 Mixed	**-1.73227** Mixed
Marcus	Information Systems/ Business	Emporium	By the end of the fall semester	Failed College Algebra	.93092 Mixed	1.00332 Mixed	-0.47433 Positive	**-1.94761** Neutral	**-2.68492** Negative
Sparrow	Computer Science	Emporium	No	No	1.32982 Negative	**1.59805** Negative	.54518 Negative	**-1.85742** Mixed	**-2.93501** Mixed
Alana	Biology. Unable to declare.	Emporium	No	No	1.32982 Negative	0.43182 Negative	0.52723 Negative	-.9085 Mixed	**-3.30978** Mixed

All five participants placed into an emporium remedial mathematics class, and the participants' intended majors were actually either STEM (Computer Science or Biology) or Business (Figure 31). Notably, only the non-STEM majors persisted in their emporium remedial mathematics courses. Ellie Blue was listed as a persister in the departmental mathematics data because she passed into College Algebra on her second placement test in the fall. However, she remained in the emporium course due to scheduling issues and did not persist through it (failed).

All five of the participants presented mixed or neutral beliefs about their mathematics abilities and their motivation to learn mathematics. STEM students (Ellie Blue, Alana, and Sparrow) expressed positive beliefs about their mathematics abilities and motivation to learn math in high school but negative beliefs about their mathematics abilities and motivation to learn math at the university. In contrast, non-STEM majors (Edna and Marcus), expressed mixed or negative views about their mathematics abilities and motivation to learn mathematics in high school but positive views about their mathematics abilities and motivation to learn mathematics at the university.

All five of the participants presented mixed or negative views about their remedial mathematics teachers. While they may have stated their remedial mathematics teacher was a nice person, the STEM majors had more negative perceptions of their remedial mathematics teacher as an academic support. This negative perception was partially due to their inability to declare or pursue their STEM majors and coursework until they completed their mathematics prerequisites. This intensified their desire to get the academic support they needed from their teacher. Although the non-STEM majors did share they preferred to have a mathematics teacher that actively teaches and engages them in their learning, their perceptions of their remedial mathematics teachers were less negative. These more neutral perceptions may be related to Edna and Marcus' ability to leverage socio-academic supports outside of their mathematics classrooms.

Of the five participants, only Edna expressed positive perceptions pertaining to academic and social integration on the study survey. In her interview, she indicated that her positive perceptions of socio-academic integration were partially related to her close childhood friends that came to the university with her and provided her with certain socio-academic supports. She also expressed that her positive perceptions of socio-academic integration were also partially related to her direct admittance into the Business School and her business courses, despite her remedial mathematics course placement, which motivated her to complete her mathematics prerequisite and "catch up" to her peers in her business program. Marcus had mixed views of his academic and social integration. While he struggled to integrate as a first semester transfer students and within his emporium course, he did develop relationships with peers and his advisor and take advantage of institutional academic supports. Marcus was also the only participant who expressed that others, specifically his parents, had positive perceptions of him and his academic abilities. The three STEM majors had negative perceptions of social and integration due to factors that are described below in detail.

Thematic Cross-Case Findings

In the sections that follow, I focus on three more general themes that I identified through the cross-case analysis, each of which addresses the sub-questions stated above. First, I unpack the meaning behind the participants' perception of teacher ratings. Second, I argue that, compared to the non-STEM majors, the STEM majors had differential experiences in their emporium developmental mathematics courses due to institutional barriers that compounded the negative effects of their remedial mathematics course placement. Third, I consider the participants' agentive behaviors, their leveraging of intrapersonal and socio-academic assets and the ways they sought to circumvent institutional barriers to achieve their academic and career goals.

Perceptions of the Teacher

The participants' negative perceptions of their emporium courses negatively impacted their perceptions of their remedial mathematics teachers. During the interviews, all of the participants wove negative commentary regarding their emporium courses into their responses about their remedial mathematics teachers. As a group, they also expressed that the fact that the emporium courses were online seemed to constrain how the emporium course instructors interacted with students and this, in turn, colored participants' evaluations of their instructors.

The two participants with higher perceptions of teacher scores clearly attributed their challenges to the emporium course structure than the teacher specifically. In contrast, the three participants with lower extreme perception of teacher scores specifically attributed their challenges in their emporium courses to teacher behaviors. Their commentaries reflected their beliefs about the way mathematics should be taught and learned. Specifically, the participants with lower extreme perceptions of teacher scores highlighted that, when challenged by the remedial mathematics content, they desired more instructional support from their teachers.

To support the claim about the interconnectedness between participants' views of their remedial mathematics instructors and the course structure, I present the perceptions of teacher cases from least to most extreme. It is worth noting that none of the extreme cases from the analytical sample had positive perception of teacher scores based on their survey responses. Therefore, all five of the case study participants had negative perception of teacher scores. Of this group, Ellie was the mean perception of teacher case (i.e. the least negative), so I start with her qualitative views of her teacher.

Ellie. Ellie had a 'perception of teacher' score that fell just below one standard deviation from the mean (-1.19202). Despite this, in the interview, Ellie did not report having a positive perception of her emporium remedial mathematics teacher because her remedial mathematics class violated her expectations based on her prior mathematics learning experiences and her professed mathematics learning needs:

> I'm a visual learner. I have to have you explain stuff, things to me, even if it's already, and I already understand it. If I don't have the resources, I can't really do well, and I didn't have that in [the emporium course].

Ellie attributed part of her frustration with the emporium course to the limited interactions she had with her instructors:

> We didn't ever talk to the professor, except for when we had, um, like, when she would hand back a test. They did say that you could ask questions in class, but every time you would ask a question, it was just one of those, like, 'Do it yourself' types of things, and they expected you to work it through yourself, while they were just standing over you kind of and correcting what

> you did wrong, but not actually explaining why it was wrong and how to get the correct answer.

Despite her negative commentary about her remedial mathematics instructors, Ellie attributed her challenges in her emporium course to the online learning platform more than her teachers directly:

> I would just sit there for three hours, and I was so inclined to procrastinate and just get my mind off math because you're just sitting there not doing anything. Like, there's no, there's no instruction. There's nothing being, like, given back to you I guess, so you're just kind of sitting there. You're on your laptop. You can just swipe over and watch a YouTube video, get on Netflix, that kind of stuff. Um, and it just, it's very hard to stay focused on math and getting to that direction where you need to be for your major. I ended up failing the class because I've never been in a math class where you're not actually taught, especially a three-hour math class where you just sit there on the computer. I don't really like computer math. I just don't find that helpful and the, um, like, the book didn't really explain things. Usually, you need someone to explain to you. I'm not, like; I won't learn unless someone is explaining it to me, especially in math. I was just spending, like, three hours every Tuesday and Thursday just looking at a computer, not being taught anything, and not really understanding.

Ellie perceived mathematics as conceptual and desired to understand the concepts, but she did not view the online platform as supportive of her conceptual understanding:

> Math is definitely concepts, and there was no, like, comprehensive learning of, like, 'This is the concept, and this is how you use it, and this is why you use it.' In [the emporium course],...the [computer] explanations were never really clear, but you'd expect them to be clear, especially since it's, like, a developmental math course, but nothing was clear, ever. I just, I don't understand that.

Edna. Edna had a perception of teacher score that fell just below 1.5 standard deviations of the mean perception of teacher score. Like Ellie, Edna shared that if she did not understand her remedial mathematics content, she could "ask for the professor and TA, and they'll break it down and teach it to you." However, she said she would have preferred "more teaching" when she was in the emporium course. Like Ellie, Edna also responded to questions about her remedial mathematics teacher by discussing challenges with the class structure. Edna attributed her motivation to persist to her dislike of the emporium structure:

> In [the emporium course], it was pretty much a self-paced program. It was online, do the assignments type of thing, and it was at 8:00 am, and that was very hard for me. So, the professor told me that the sooner I get things done, the sooner I won't have to come to class to do it. So, I pretty much tried to do, like, three [units] a week. Like I, I kept on going, like, ahead of time, so I [could] stop having to go to the class.

Edna also contrasted her emporium course with her College Algebra course, saying she appreciated when she switched to College Algebra because it "was completely different from [the emporium course]. I mean, we did have a[n], um, an actual professor that taught us."

Marcus. Marcus was one of the three interviewees who held negative views of their emporium mathematics instructor as academic support. Marcus had a perception of teacher score that fell just below 2.5 standard deviations from the mean. Marcus first shared the challenge of the online classroom environment: "If you're used to like, a teacher just on the board, you know, teaching like that, instead of just you being by yourself on a computer, then (the emporium course) like, it's kind of hard to get used to." He also described his emporium course as “weird” and “distant” saying:

> I don't know. It just felt weird honestly, to me and it wasn't like a teacher writing on a board. It was just like, us on a computer, just learning ourselves in our own little world and space and bubble. That kind of...like, makes me procrastinate in actually getting help.

Despite this, Marcus did reach out to his teacher to ask her for help when he had difficulty in his emporium course, but his teacher’s support did not improve his outcomes: “She gave me some pointers, and I thought I did, you know, well in studying.” Marcus did not do well on the subsequent test. He reflected, “I guess I didn't do enough,” but his inability to improve with his remedial mathematics teacher’s support led him to seek mathematics support elsewhere.

Sparrow. Sparrow was the second interviewee who articulated negative views of the emporium course instructor as academic support. Like Marcus, Sparrow had a perception of teacher score that fell just below 2.5 standard deviations of the mean. As was true with Ellie, Sparrow shared that his emporium remedial mathematics class contradicted his prior mathematics learning experiences, but he spent more time discussing his beliefs about mathematics teaching and learning:

> In Ghana, like the schools, I went to, how they teach math is like, you know, together. So, it's not like here. Here you have to…learn everything by yourself, but there, the teacher is, you know, in the classroom teaching, like step by step, all the way.

Sparrow attributed his challenges in remedial mathematics to his need for specific teacher practices, such as having the teacher, “actually call you, you know, to come up front to solve.” He said he preferred to be taught mathematics in, “a traditional class,” where he could, “actually see how the teacher is solving [the mathematics] and then, learn alongside,” where, "if I don't understand it, I'm going to ask questions." Like Edna and Marcus, Sparrow believed that if students had questions in his emporium remedial mathematics class, “We can totally ask for help, you know, from the instructor or the TA, and then, they will help out.” However, Sparrow did not believe this level of teacher-student interaction supported his understanding of the mathematics, “As far as grasping the whole thing going on, naw. You are not really learning.”

Alana. Alana also articulated negative views of her emporium course instructor as academic support. She had the most extreme perception of teacher score which fell three standard deviations below the mean perception of teacher score. When asked about her emporium remedial mathematics teacher, Alana described her as, “wonderful,” “lovely,” and “nice,” but followed those descriptors immediately with, “I just, I felt like I wasn't being taught anything. I wasn't really learning. I was just trying to get work done.” Alana stated that "I didn't have a problem with um, with my professor. It was more so just the delivery. You know, I was thinking that it would be like a[n] actual, like, a[n] actual class." Like Sparrow and Marcus, Alana's beliefs about mathematics teaching and her expectations for her mathematics learning negatively impacted her perceptions of her teacher.

The Differential Experiences of STEM and Non-STEM Majors

The STEM majors, namely Ellie, Alana, and Sparrow, reported having more negative socio-academic experiences at the university than their non-STEM peers, namely Edna and Marcus. The former group were clear that this was due to their placement in their emporium courses. That is the combination of emporium course placement and intended major, resulted in the STEM majors developing more negative beliefs about their mathematics abilities and perceptions of their peers and their degree of social and academic integration than the non-STEM majors, reducing their motivation to persist in their remedial mathematics classes and to pursue STEM altogether. Institutional factors, such as their ability to declare their STEM major and their ability to take courses for their major with their STEM peers, significantly affected the STEM majors' perceptions of themselves, their remedial mathematics classes, and their intended STEM major. Socio-economic factors, such as not having the financial means to live on campus and having heavy work and family responsibilities, compounded the adverse effects of two of the STEM majors (Sparrow and Alana), further degrading their beliefs, perceptions, and motivation to persist in their remedial mathematics courses and for Alana, in STEM altogether.

The ability or inability to declare their major. One of the most salient sub-themes was that a participants' ability to declare and be accepted into the college of their major of choice had significant impacts on their beliefs about themselves and their abilities, their remedial mathematics courses, their motivations to persist through their remedial mathematics requirements and ultimately, their motivation to persist in their STEM major. This sub-theme is most evident in the contrasting stories of Alana and Edna.

Alana was unable to declare Biology as her major due to her placement into remedial mathematics. Not surprisingly, this led Alana to perceive her remedial mathematics class as a gatekeeper, preventing her from obtaining the Biology degree she desired:

> Yeah, like, when my major read on my sheet, like, Letters and Sciences, I'm like, ‘Why am I in Letters and Sciences? I've picked Biology as my major going in when I did the application,' and then, I also was thinking since I got into the Honors College that maybe it would push me to priority to like, direct admit into the major, but I guess not. I couldn't do it for Biology yet, only because like, I still haven't even taken a natural lab. Like, I have to take, I have to take Pre-calculus, and then I have to take Calculus because I can't take, um, the lab, which is like 160 and 161, until I'm taking, like, Calculus. Calculus was a prerequisite for that lab, and that's one of the gateways that I have to do.

As indicated in Alana’s statement above, her placement into remedial mathematics also conflicted with her high academic status as an Honor’s College student and challenged her self-efficacy as a STEM student. The summer before her first year of college, Alana interned at a local research hospital and conducted and presented research on HIV. She reported that this experience reinforced and strengthened her STEM identity, leading her to consider, “Maybe I'll get, like, my Ph.D. in biology or something." Unfortunately, her placement into remedial mathematics at the university left her thinking, "I can't even get into the freaking math class." Her inability to meet the Biology prerequisites caused her to doubt her academic abilities and question the validity of dominant deficit narratives relating to minority achievement:

> It was like, it was kinda disheartening, like, only because, you know, like, okay I'm in college. I'm here. I got in. Like, I must be doing some something right, but it's very like, disheartening. Especially because you're, I don't know. I guess because of the ideas that are like kinda still, like, maybe, pervasive. Like, oh, okay, like maybe, like maybe I'm not good enough, or things like that, and especially, especially being a minority.

Ultimately, Alana shared that her inability to declare Biology reduced her motivation to pursue STEM: “I really do have a strong interest in Biology, but like, *the math…*” To compound matters, Alana’s academic proficiency and high status in her non-STEM coursework led non-STEM faculty to try to recruit her into their non-STEM programs. In particular, Alana shared that, “The head of the African American Studies program really wants me to think about doing African American Studies.” Alana’s recruitment from non-STEM faculty into non-STEM programs made Alana feel valued and capable, something she did not experience from the Biology department at the university, further reducing her motivation to pursue a Biology degree and increasing her motivation to move out of STEM.

In contrast, Edna was admitted directly into the Business School as a Business major. Although Edna claimed she, “really didn't care for” mathematics” in high school, she presented herself as having high self-efficacy in her university mathematics, most likely because her remedial mathematics course placement did not prevent her from pursuing her Business degree. Edna admitted that "The majority of Businesspeople place straight into calc," and she also shared that her Business counselor advised her that her placement into remedial mathematics initially put her behind in her Business program, but she, “Became better on track by moving up to [College Algebra]” within the same semester.

Like Alana, Edna did not “like being behind,” but she did not experience being disenfranchised by the Business School or her business program due to her placement into remedial mathematics. Instead, she was counseled on the courses she could take that would keep her on track for an on-time graduation with her Business degree: “In case [Business majors] don't place straight into calc., they can always take [College Algebra] and then, um, try to fit in Business Stat over the summer, or in the fall.” Edna’s Business School had a plan for students who did not place into Business Calculus initially, and this plan was shared with Edna when she placed into the emporium remedial mathematics course. She knew she had a 4-year pathway to graduation with her Business degree, so, unlike Alana, Edna did not perceive her remedial mathematics class as a barrier to obtaining her degree, and she did not develop a deficit perspective of her mathematics or academic abilities as a result of her remedial mathematics course placement.

Edna also grew up locally and recognized students from her high school and the school district in her remedial mathematics class, noting that, “there was a lot of, uh, black people, black people from around this area…the majority of people were from [my local school district].” She attributed this overrepresentation to poor K-12 mathematics preparation: “I was like, [my school district] isn't probably doing a good job preparing us for college in math because we were all struggling. Um, yeah." Edna shared that Black students from her area, "had a lot of family struggles or financial struggles. So, school wasn't always um, a priority for us. It was more like living, what to eat, having a roof over our head, all those other things that came into place. School was just like, do it because that's good, not do it because of career-wise and stuff like that." She noticed:

> A difference when, like, meeting people that grew up with a lot of privilege. School was their job. Like, [they] didn't have to have a part-time job. All [they] have to do is focus on school and uh, I think that was more beneficial for them and a disadvantage for us so, like, that's why we're a little bit behind.

Edna's believed that socio-economic privilege was racialized and impacted access to high-quality mathematics instruction in high school, university mathematics course-taking and her experiences at the university. This belief played inter her broader observations of racial segregation at the university:

> It's like, you can feel the separation, but at the same time, I try not to think about that because, like, one of my reasons for not going to an HBCU is because I want to meet other people. I want to have different friends, but even being here you can see, we're diverse, but we're separated.

Unlike Alana, Edna attributed her placement into remedial mathematics to a lack of racial and economic privilege, which she presented in the context of a distinct, racialized experience. She was one of many Black students from her local school district enrolled in the emporium remedial mathematics classes, so she did not see herself as an outsider, and she was not concerned over how others perceived her placement into remedial mathematics. Therefore, Edna did not attribute her placement into remedial mathematics as relating to academic inability, but to differential opportunities to learn advanced mathematics, saying it was, “like everyone else had practice. Everyone else had camps, everyone else had all this extra assistance, and I didn't.”

Alana's inability to declare her Biology major. Her negative beliefs and perceptions that resulted from her lack of acceptance into Biology thwarted her motivation to persist in her remedial mathematics course and STEM. In contrast, Edna's ability to declare and pursue her Business degree and the fact that she attributed her remedial mathematics course placement to differential opportunities to learn preserved her self-efficacy and positively impacted her perceptions of her remedial mathematics course and her motivation to persist. Even though Edna reported that she had negative mathematics experiences her senior year of high school, she was confident in her ability to succeed in her remedial mathematics course at the university, claiming she, “didn't really have a struggle with [the emporium course]” and liked that, “It lets [her] get ahead on [her] own pace.” She was highly motivated to move into College Algebra from her emporium course in the fall semester, saying, “I rushed myself,” but it was, “doable because I had time to fit it in.” Since the course was online, she also felt she had no excuse not to work ahead:

> It made it hard to sit down and do it, but at the same time, there wasn't a time I [could] be like, ‘Oh crap. I woke up late. I missed the thing.' It was just like, ‘All right. I didn't do any math yesterday. I'm gonna stay up tonight and listen to music and do it then.' So, it was just easy to push myself like, ‘All right. Come on. You've got it.'

As evident in Alana and Edna’s stories, these young women had differential experiences in remedial mathematics due to whether or not they could declare the college of their major of choice. Alana’s inability to declare Biology as her major because of her remedial mathematics course placement had detrimental effects on her perceptions of her remedial mathematics course, which she saw as a gatekeeper. Also, Alana's mathematics self-efficacy and STEM identity were negatively affected by her inability to declare her major, reducing her motivation to pursue STEM altogether. Alana’s success in non-STEM courses and recruitment out of STEM by faculty in non-STEM programs boosted her non-STEM identity, further deterring her from pursuing STEM.

In contrast, Edna was admitted into the Business School and provided with a clear path to on-time graduation, despite her remedial mathematics course placement. Thus, Edna did not perceive her remedial mathematics course as a barrier to her Business degree. She attributed her placement into remedial mathematics to a lack of privilege and not to a lack of ability, and this resulted in her perception that her remedial mathematics course was as an opportunity to "catch up" to her more privileged peers. Edna's more positive perceptions of her remedial mathematics course and her ability to preserve her mathematics and academic self-efficacy supported her motivation to persist.

The ability or inability to pursue coursework for their major. Some STEM majors enrolled in remedial mathematics are permitted to declare their major but are not allowed to take the courses required for their major because of mathematics pre-requisites. This institutional factor also had significant adverse effects on the STEM majors’ beliefs about themselves, their perceptions of their remedial mathematics courses and peers, and their motivation to persist in remedial mathematics and STEM. These adverse effects are evident in the stories of Ellie Blue and Sparrow, the two Computer Science Majors, which can again be contrasted with Edna, but also with Marcus.

Ellie had declared computer science as her major, but she was unable to take computer science courses with her computer science peers:

> Being placed in [the emporium course], I wasn't able to take any computer science courses anyway. So, I was just taking gen ed. So, I kind of, like, I had declared my major as Comp Sci, but I wasn't doing anything with Comp Sci.

Her placement into remedial mathematics conflicted with her identity, particularly her African identity, “I didn't want to go to get help and things like that because I was already, like, failing my family,” and her computer science identity:

> I have a lot of computer science friends because when I was applying, and we were all going to orientation together and all that kind of stuff. We were all talking about, like, the Comp Sci classes. What class we were gonna try to get into, and then, I couldn't get into any of those classes.

Ellie believed that, as an African Computer Science major, she did not belong in remedial mathematics, and this reduced her motivation to integrate with peers in her emporium course:

> I never really had any type of connection or relationship. I would just walk into class and do my work. I didn't really talk to anyone in [remedial mathematics], mostly because I just, I didn't like the fact that I was in [remedial mathematics] (laughs) because the first question any college

> student asks is, 'What's your major,' and I don't like answering that question.

Finally, Ellie's inability to integrate with her computer science peers negatively affected her mathematics self-efficacy and her STEM identity: "Before [this university], I really loved math, never really struggled in math, and really liked it." It was something Ellie claimed she, "wanted to do for fun." She was attracted to computer science because she liked, "computers and math. So, it was like, two great things." However, Ellie's placement into remedial mathematics made her question her mathematics abilities and her computer science identity:

> So, when people would ask me what my major was, and I would say Comp Sci, and they would say, 'Oh, which, um, comp sci class are you in?' And I would just kind of be like, 'Uh, I'm not in any because I can't because of my math class.' And people would be like, 'Why?' And then I have to explain that I'm in [remedial mathematics], and then I, not like, I would get kind of like a negative reaction, but I just didn't like having to tell people. It just didn't feel, it felt kind of like I was failing.

Ellie's lack of confidence in her mathematics abilities at the university and her lack of integration with her computer science peers ultimately led her away from pursuing her STEM degree altogether:

> Uh, the math definitely has a prominent, like, impact on my decision to change my major. Confidence in what you're doing is, like, like, number one, and if you keep, like, like, not succeeding at the things you want to succeed at, it kind of like takes away from what you want to do. So, because

> I'm, like, not in the right math class, and I'm behind, and I can't take any comp sci classes, I just, I don't see the point because then it doesn't make me feel like I can do it. I don't like feeling behind. I don't see the point in continuing to, like, put myself in, like, this position when I don't really need to. I don't like failing. I don't think I can continue to fail.

Like Alana, Ellie perceived her placement into remedial mathematics negatively because it was a barrier to her computer science courses that were required by her major. This one institutional barrier had severe consequences. Ellie was unable to integrate academically with her computer science peers, and this challenged her African and computer science identity, making her feel ashamed. This shame limited her motivation to integrate socially with her computer science peers and academically with her remedial mathematics peers, restricting her access to peer support entirely. Like Alana, Ellie's negative experiences relating to her placement in the emporium remedial mathematics class led her away from pursuing a STEM degree.

Like Ellie, Sparrow was a Computer Science major and his inability to meet his remedial mathematics requirement was preventing him from moving forward in his program entirely:

> If, if I don't pass this class, then that means I'm not going forward with any, because right now I'm done with, like, most of my generals. Right now, the only thing holding me back is the math. If I don't take them, like pass math and then take like, uh, pre-calculus, I can't do like my, my major.

The pressure of not being able to move forward in his program because of his mathematics prerequisites left Sparrow with extremely negative perceptions of his remedial mathematics course, peers and university supports. When discussing his peers in his remedial mathematics class, he said "I wouldn't say there is much support over there, because they are also focused on getting stuff done and so, I don't feel like there is that much support." Also, although Sparrow was aware of university math supports, such as on-campus math tutoring, he didn't feel like they would benefit him:

> I have to actually get some idea [of] what's going on in the modules before I can go ask questions, but I'm not getting what's in the module. So, if I, if I go ask questions, I'm just wasting their time.

As a Computer Science major, Sparrow said he was mandated to meet with an advisor once per semester, but he perceived his computer science advising negatively as well:

> You just go online. You just pick one of them and book an appointment, and then, when the time comes, you just go to the advisor, [and] talk [about] whatever you want to talk about before registering. That's, that's it. When next semester comes, it's probably going to be a different advisor. I don't see the point of doing that.

The impact of not being able to move forward in his computer science program also had adverse effects on Sparrow's interest in and motivation to learn mathematics. Although in high school, Sparrow said he, "didn't have any problem with math," He shared that, "Math is not interesting to me," attributing this to, "not [going] ahead in [remedial mathematics]." However, Sparrow did say he understood, "the computer stuff easily, you know. Like the practical stuff, I, I can totally get into it with, you know, ease." Sparrow retained his computer science identity despite his negative experiences in remedial mathematics. Like Ellie, Sparrow's perceptions of his remedial mathematics course, peers and university supports were negative, but unlike Ellie, Sparrow did not discuss moving out of STEM.

In contrast to Ellie and Sparrow**,** Marcus, like Edna, was not prevented from completing any general education requirements during the year of this study, so he did not perceive his remedial mathematics course as a barrier. Like Edna, Marcus did not develop negative beliefs about his mathematics abilities or have negative perceptions of his peers or the university. Marcus did share that during his first semester at the university, he felt like he was, “at a disadvantage cause, like, there's some people been here since like, freshman year and they've already had their friends and connections like, since then.” However, by the end of his first year, Marcus said he acclimated and had friends on campus. Marcus also, “definitely noticed that” Black students were overrepresented in his emporium remedial mathematics class, but said that it, “didn't really bother [him] at all.” Like Edna, Marcus did not internalize the overrepresentation of Black students in his emporium remedial mathematics class as the result of his, or his Black peers’, academic inabilities.

Also similar to Edna, Marcus had negative beliefs about his mathematics abilities in high school but positive beliefs about his mathematics abilities at the university. Marcus shared that in high school, he “was never really like a real strong math person.” He attributed his challenges in math to math testing anxiety:

> Questions, like, I'm not expecting pop-up, and when I see 'em, it just throws me off. It's like, I just draw a blank, and I just make silly little mistakes, and then, I look back on it, and I, and I think to myself, ‘Like, dang, why did I do that?’

Despite his math test anxiety, Marcus said he was still “always able to pull off, like, a decent grade in [high school math]”because, “When I know I need to get something done, I just, you know, get it done. It's sort of, like, how I've been raised.” Marcus shared, “I didn't really like [the emporium class] at first because I felt like I should've been like way more ahead than taking [the emporium] class,” but, like Edna, his dislike for the emporium course led Marcus to, “push [him]self.” He also said he was motivated to learn his remedial mathematics content to, “get this prereq out of the way for my degree.” He seemed to have a positive mindset, saying, “If I have to do this, I can.” Thus, like Edna, although he did not feel that he was, “a strong math person” in high school, Marcus certainly had a high degree of self-efficacy in meeting his remedial mathematics requirements. Marcus also had positive perceptions of a variety of university resources, describing his Letters and Sciences advisor as, “a pretty cool person” and the university’s Learning Assistance Services (LAS) as academically supportive: “They will tell you, like, what you need to do. Like, how you need to study.”

Marcus was planning to switch his intended major from Information Systems (in the School of Business) to Information Science (in the College of Information Studies; STEM), based upon his advisor's recommendation. This major requires him to take an Elementary Probability and Statistics course, as well as a Pre-Calculus (or higher) course. These math courses are benchmark courses in which he needs to earn a C- or higher to continue through the program. When asked how he felt about having to take the additional mathematics requirements, Marcus responded, “I really just want to get math over with, but it is what it is. If I have to take it if that's the requirement.” Unlike Alana and Ellie, Marcus' mathematics requirements did not deter his interest in pursuing a STEM degree.

As evident in Ellie, Sparrow, and Marcus' stories, the Computer Science majors had differential experiences at the university due to their remedial mathematics course placement and whether or not they could complete their computer science coursework. For Ellie, not being able to complete her computer science coursework until she passed remedial mathematics led to conflicts with her African and Computer Science identity and prevented her from integrating with her computer science peers, resulting in negative perceptions of her remedial mathematics course and beliefs about her mathematics abilities. Her STEM identity was challenged, in spite of her history of high mathematics self-efficacy and motivation to learn mathematics. Ultimately, her motivation to learn mathematics and pursue computer science diminished. Because Sparrow had already met all of his general education requirements, except for his mathematics, he faced even more pressure. If he did not complete his mathematics prerequisites successfully, he would not be able to continue in the computer science program. The gatekeeper status of Sparrow's remedial mathematics course led him to develop extremely negative perceptions of mathematics, and peer and university supports. Unlike Ellie, Sparrow's self-efficacy in computer science was not negatively affected by his inability to pursue computer science courses. In contrast, Marcus was undeclared and could take any of his general education requirements while enrolled in his remedial mathematics course. Therefore, he did not perceive his remedial mathematics course as a barrier, and, like Edna, his beliefs about his mathematics abilities and motivation to learn mathematics, his perceptions of his peers and university resources were positive. He even considered moving into a STEM program.

Leveraging Intrapersonal and Socio-Academic Assets

The participants who persisted through their emporium courses (Marcus and Edna) reported leveraging a variety of intrapersonal, academic and social assets in ways that supported their persistence in their remedial mathematics courses when faced with challenges in their emporium classes. They were clear that this helped them to persist. In contrast, those who did not persist, Alana and Sparrow more than Ellie Blue, faced socio-economic barriers that prevented them from accessing and leveraging such assets. In particular, unlike Marcus and Edna, Alana and Sparrow did not have the financial means to live on campus, so they resided off campus with their parent(s) and siblings. Their family's financial needs required them to contribute to their household finances by working 30 hours or more each week. Their work responsibilities, household responsibilities, and off-campus housing limited Alana and Sparrow's time on campus, reducing their access to socio-academic supports such as peers, teachers and university resources. However, like Edna and Marcus, Alana, Ellie and Sparrow were actively engaged in agentive behaviors that focused on their undergraduate degree attainment. The data that supports these two claims is evident in the different stories of the non-STEM majors (Edna and Marcus) and the STEM majors (Alana, Ellie, and Sparrow).

Financial motivation. To varying degrees, the participants cited financial or economic reasons for persisting or being challenged to persist. Edna's family and childhood experiences led her to strongly believe that a college education would result in socio-economic benefits and this was a strong motivator for her:

> I have a community of people that's helping me push, but they're, like, also busy too. Like my family is all trying to go back to school, or they have kids and stuff. So, they're like, they're, I know that they're always there for me,

> but it's, it's more like a personal drive. I, I don't want to live the same life I grew up in. I don't want to bring kids into the world living the same life that I grew up in.

Edna's socio-economic status caused her to have financial challenges, so she worked part-time during the school year and planned to work full time over the summer, "but I can't work full time now because it's just, it's too much, but I wish I was. The money would be helpful." Although she faced financial challenges, Edna did live on campus in her living and learning community, and she did not have to work full time during the academic year. These factors supported Edna's ability to leverage her high degree of financial motivation when she learned she could move to College Algebra from her emporium remedial mathematics class:

> So, it was just like, trying to just get it over with, especially knowing that I'm gonna have to take [College Algebra] eventually, and um, also it's free. So, if I, um, I've already paid for [the emporium course], but if I got it done in that semester, [College Algebra] would be free.

Like Edna, Alana believed that a college education would lead to socio-economic benefits, and this highly motivated her. She also attributed her beliefs to her family and childhood experiences:

> My mom had me when she was 15, and like, how I, how I was in high school, like getting good grades, getting straight A's, doing all these extra-curricular activities. That's exactly how she was, but then, you know, like, she ended up, she ended up getting pregnant, and so, I think that, like, we had such a difficult time. So, she had to, she had to work multiple jobs and

> stuff to get back on her, to get back on her feet. And you know, we moved around a lot, we stayed with a lot of family members. There were times where me and my sisters, um, didn't actually like live in the same house because like family members didn't have enough space for all of us. As that happened like, I always liked to read and write even when I was younger, and I think, um, because you know, that's how she was in school. Even though, you know, she did get pregnant, and she didn't necessarily end up on the path that she wanted uh, wanted to be on, I think that she still instilled that in me. And I think that I never wanted to be in the same situation as like how, like how my mom was starting out when she had a difficult like you know, even getting us a place where, you know, we could all live together. And I just, I just never wanted my kids to have to go through that. Like, when I have kids, like, I want them to be able to live, like comfortably. So, it made me more inclined to like school. Like, I *really* liked school. I was always like, advanced and things like that. And even from a young age, like, I was looking at colleges by like, the fifth grade. I knew that, you know, education is going to get you, like, where you need to be.

Unlike Edna, Alana faced several barriers that prevented her from leveraging her high degree of financial motivation to support her persistence in her remedial mathematics course, mostly because, despite her acceptance into the Honor's College, Alana did not receive enough financial aid to provide for her on-campus housing. She lived off campus, commuting "an hour and a half" each way, and indicated early on in her interview that housing security was an ongoing concern:

> I'm still currently in the process of trying figure out um, you know, like where I'm living and stuff next year. Um, I'm moving in with my grand mom, as opposed to living with my parents. They were supposed to help me with an apartment, but now, I don't know if that's gonna work now.

Alana's need to pay for uncovered college and commuter expenses required her to work at least 30 hours a week while taking full-time coursework:

> So, I get, um, like, my federal loans. I didn't really get much uh, financial aid, and I have to pay the excess, like, with my own money. So, that's why I'm working part-time. So, I have to save up this summer for the amount that I know my excess is gonna be, which was like 3,000 for both semesters. So, I want to try to save that up. My parents are putting the car in my name. So, I'm gonna have, like, a $380 car insurance payment. I have to pay my phone bill, upkeep of the car. It's just; it's a lot.

Alana's, housing, work, and family situation also limited the time she had to focus on her academics and negatively impacted her academic motivation and sense of well-being:

> It's really overwhelming. It's definitely a lot different when, you know, I'm commuting from an hour and a half away. I have to work 30 hours a week, and I still have to figure out what times I'm going to do my homework, and do my papers, and you know hang out with my friends, so I have a social life because I don't want to be depressed. And then, because I live at home, I'm still expected to do certain chores and everything that goes on in the house. So, I don't know. I kinda like have been getting like a little depressed this semester because my grades aren't where, like, I want them to be. Or,

they may not be where I want them to [be] because, like, I'm so used to that, and it's like, I kinda feel my motivation to do things slipping away.

Thus, although Alana was highly motivated by the socio-economic benefits her education could provide, her financial barriers required her to divert her financial motivation to earning the income she needed to pay for her courses, commute, and housing which negatively impacted her persistence in her remedial mathematics course.

Sparrow's socio-economic factors and previously provided interview data reinforce the findings presented through Alana above. As mentioned earlier, Sparrow lived at home with his mother and younger siblings. As the oldest child in his household, Sparrow also had “to work and then go to school at the same time,” to contribute to his family's financial resources. Sparrow worked “at least full time” off campus, and his work and family responsibilities impacted the time he was able to dedicate to mathematics.

Time was an obstacle that Sparrow frequently mentioned throughout his interview. He shared that twice he, “didn't finish” his remedial mathematics course requirements in time, which caused him to fail and have to re-take the course automatically. Given his family and work responsibilities, Sparrow felt to complete the online emporium modules, "The timeframe is…not enough because we are pretty much doing everything by ourselves. So, if you are going to learn everything by yourself and then understand it, 15 weeks is not enough.” Sparrow’s extremely negative perceptions of socio-academic supports that were available on campus, such as his peers in his remedial mathematics class, his academic advisor, and institutional mathematics supports likely stemmed from the limited amount of time he had on campus to leverage these resources for his academic success. Like Alana, Sparrow's work and family responsibilities restricted his opportunity to access these socio-academic supports, leading him to perceive them as useless.

Socio-academic peer support. To varying degrees, the participants also cited the role peer relationships played in their persistence. Again, Edna's ability to leverage her peer relationships contrasts Ellie, who, as previously discussed, was segregated from her peers in computer science and isolated herself from her peers in her emporium course due to her identity conflicts and shame. In contrast, Edna came to the university with built-in peer support as some of her university peers were friends she had known since elementary school. When Edna struggled in her remedial mathematics class and did not get the mathematics support she desired from her instructor, she said: "I went to my friends that know how to explain it down to me." These friends included her best friend and her best friend's twin: "Me and her [have been] friends since second grade, so it's her, [and] her twin sister. We all study together."

Leveraging the academic support of her peers was especially fruitful because Edna's best friend was enrolled in a corequisite remedial mathematics class, "getting 100s," when Edna was in her emporium remedial mathematics class. Edna believed that her friends were her best mathematics support system because although, "there's a lot of math tutoring that's said to be available on the [mathematics] resource page, their schedules are packed up or very like, inconvenient." She also believed this was true for her mathematics teacher: "His times [are] also difficult to make, and it's only like, twice a week. " Edna preferred to receive her mathematics support from her friends because they were, "more flexible with time." While both Edna and Alana faced academic challenges in their emporium courses, Edna was able to respond to those challenges by leveraging the socio-academic support of her peers, while Alana's financial issues and off-campus housing limited her ability to do the same.

The positive perceptions of parents. As stated previously, Marcus was the only participant who reported that others, specifically his parents, had positive perceptions of his academic abilities. Marcus' report that his parents had positive perceptions of his academic abilities contrasted with Ellie, who reported that she was "already failing her family" because of her remedial mathematics placement. Marcus shared that his mother and father had high expectations of him and saw him as perhaps, more brilliant than he felt at times:

> There [are] people who've always had, like, high expectations of me, and sometimes I feel like it's like they, they like, they would say like oh, you're an Einstein and stuff…I don't even really feel that honestly. I mean I; I am smart. I just don't put in the effort. I am smart, but, like, sometimes I feel like people take it to, like, another level. Um, so like it is kind of like how I'm raised, like, people expect great things and stuff out of me.

Marcus was "very appreciative of" his parents' positive perceptions of him, and he leveraged their beliefs about his abilities to motivate himself to persist when faced with challenges in his remedial mathematics class by setting "a goal" to meet their expectations and finding a way to do so. He reflected his parents' positive beliefs about his abilities in his comments about his ability to persist in his emporium course: "I just, I have to do this. So, I can do that. That's what really got me through that, and you know, pushing me through. Yeah." In contrast, Ellie's shame of not meeting her parents' academic expectations negatively impacted her motivation to persist in her remedial mathematics class and Computer Science.

Socio-academic supports provided by the university. In addition to leveraging his parents' positive perceptions of his academic abilities, when faced with challenges in his emporium course, Marcus took advantage of socio-academic supports that were freely provided by the university. His leveraging of university socio-academic supports contrasts Sparrow, who, as you may recall, responded negatively to the usefulness of such supports. Marcus lived and worked on campus, and during the academic year, he only worked part-time one or two days a week, "max, and only for like five hours" per day. Thus, when Marcus did not improve in his remedial mathematics class after meeting with his remedial mathematics teacher, Marcus shared his struggles with his academic advisor. Marcus' advisor referred him to free, on-campus tutoring services offered by Learning Assistance Services (LAS) and the Office of Multi-Ethnic Student Education. Marcus took advantage of both of these university supports and found that "LAS more so helps you, like, I guess, improve as a student. So, instead of tutor[ing], they will tell you, like, what you need to do. Like, how you need to study." By bringing his issues to his advisor and following through with that advice, Marcus was able to leverage both his positive relationship with his advisor and the university's academic supports that were freely available to him to help him persist in his remedial mathematics course. In contrast, Sparrow did not leverage socio-academic supports available at the university, most likely because he had limited time on campus due to his heavy work and family responsibilities, and this negatively impacted his ability to persist in his remedial mathematics class.

Circumventing institutional constraints. Although the STEM majors (Alana, Ellie, and Sparrow), did not leverage the intrapersonal, academic and social assets described above in ways that supported their persistence in their remedial mathematics courses, they were still actively engaged in agentive behaviors that focused on their undergraduate degree attainment. You may recall that Alana shared she was being recruited out of STEM by her African American Studies professor. This recruitment effort was perceived positively by Alana because she received financial incentives. Alana shared that she had been, "waiting on this STEM scholarship," but, "didn't get an award" this round. However, the chair of the African American Studies program told her he would help her, "figure out some things financially," making her feel this alternative path to her undergraduate degree would be a good choice. Thus, although Alana had strong beliefs about the benefits of attaining her degree and had a high degree of financial motivation, her socio-economic barriers limited her ability to leverage these assets to help her persist in her remedial mathematics class and her intended STEM major. Instead, they helped her identify an alternative path to attaining her degree which would result in her movement out of STEM.

Also, because Alana experienced her emporium remedial mathematics class so negatively and she had a strong desire to obtain her undergraduate degree, Alana began to research remedial mathematics. Through her independent research on remedial mathematics, Alana confirmed, "It's a lot of minority students, and not even just [here], but across the country." Her findings led her to proclaim that she was, "thinking of having a meeting with [the university] president on, you know, like what really is the point to having these people take remedial classes?" Alana's decision to investigate remedial mathematics and to challenge its morality demonstrates her high level of self-efficacy, positive agency, and resolve to counter-narrate (Nelson, 2001).

Ellie's data also demonstrates that when faced with mathematics as a barrier to her Computer Science degree, she sought out a non-STEM major so she could continue the pursuit of her undergraduate degree. Sparrow also sought out an alternative route to degree attainment. However, unlike Alana and Ellie, Sparrow’s high self-efficacy in computer science and his lack of recruitment out of the major left him searching for an alternative route to attain his Computer Science degree. During his interview, he shared that he had identified a computer science program at another university that would provide him with more time to complete his mathematics requirements:

> That school is pretty much like an online kind of thing, but they have a campus there for the resources and all that. So, I was thinking about it, and it makes sense because like for, for the math class for instance, if I know I'm going to take math next semester, and it's online, and I know I can't finish in the three months. You just go on. They [don’t] have like a specific, like a rigid timeframe for you to do it.

Thus, even though Alana, Ellie, and Sparrow were unable to leverage assets that supported their persistence in remedial mathematics, they demonstrated efficacy by actively engaging in agentive behaviors that helped them identify an alternative path to attain their undergraduate degree.

Conclusion

These qualitative findings confirmed my hypothesis that several institutional and classroom factors impacted the participants in emporium courses’ experiences, beliefs and perceptions and ultimately, their persistence. In terms of classroom and institutional factors, Edna had close childhood friends who were taking corequisite remedial mathematics classes at the university, and she recognized her high school and local school district peers in her remedial mathematics class, so she positively identified with remedial mathematics students. Edna also lived on campus as a member of a living and learning community which she perceived as "supportive" and was pursuing a Business degree which that did not exclude her from her program because of her placement into a remedial mathematics class. Her belief that her remedial mathematics course placement was not due to any mathematics inability but to her lack of privilege allowed her to maintain more positive beliefs about her mathematics abilities and her identity as a Business major. Her high degree of social and academic integration and her ability to leverage the socio-academic support of her peers also seemed to positively affect her beliefs about her mathematics abilities, her perceptions of her remedial mathematics teacher and her remedial mathematics course experience in general. These findings for Edna are significant as they reify the positive impact that academic and social integration can have on undergraduate persistence and success (Tinto, 1975, 1987, 1993 & 2007).

In contrast, Alana, Ellie, and Sparrow were STEM majors who perceived their remedial mathematics classes as a barrier to attaining their STEM degrees. Ellie's identity conflicts prevented her from seeking classroom and university supports and alienated her from her peers in computer science. Both Alana and Sparrow lived off campus and had substantial financial and family obligations. Although neither of them had children of their own, they each worked 30 hours or more every week to support their parents and siblings. On top of this, Alana commuted roughly 3 hours to campus each day. Due to the emporium course structure, even when they were on campus in their remedial mathematics classes, Alana and Sparrow had limited interactions with their teacher and classmates. These intrapersonal, classrooms, institutional and socio-economic factors negatively impacted the STEM majors' beliefs about their mathematics abilities and their perceptions of their teacher, peers, and school climate, limiting their ability to leverage university resources to help them persist in their emporium courses. Ultimately, these factors led Alana and Ellie to identify a non-STEM pathway to obtain their undergraduate degree and led Sparrow to identify an alternative computer science program through an outside university.

Participants with a lower perception of teacher score were more likely to attribute challenges in their emporium remedial mathematics classes to a lack of access to specific teaching practices that were reflective of the participants' beliefs about mathematics teaching and their expectations for learning mathematics content. Their low perception of teacher scores indicated that when challenged by their mathematics content, they wanted instructional support from their teacher, and they did not receive the support they desired in their emporium remedial mathematics setting. This finding alone did not explain Ellie, who had a mean perception of teacher score but did not persist, or Marcus, who had an extremely low perception of teacher score and did persist. However, it makes sense that Ellie could have a more positive perception of her remedial mathematics teacher but not persist if we take into account that her remedial mathematics class was a barrier between her, and her computer science peers and program. Although Marcus did have a low perception of teacher score, he did not perceive his remedial mathematics class as a barrier; therefore, he had more positive perceptions overall. His more positive perceptions, along with his ability to leverage his parents' positive perceptions of him, his close relationship with his advisor, and the university's academic supports help to explain why Marcus was able to persist, despite his low perception of teacher score.

The most significant finding was that STEM majors experienced their emporium courses more negatively than non-STEM majors because institutional barriers prevented STEM majors from declaring their intended STEM major or completing coursework for their declared STEM major due to their remedial mathematics course placement. Thus, they perceived their remedial mathematics course as a barrier to attaining their STEM degree, leading to more negative beliefs and perceptions, challenging their ethnic, academic and STEM identities and hindering their motivation to persist. These factors increased their risk of moving out of STEM altogether. This finding is particularly troubling given the overrepresentation of women (57.5% versus 46.8% university-wide) and minority students (83% versus 43% university-wide) in the emporium courses and their gross under-representation in STEM fields across the country (Funk & Parker, 2018). In the next chapter, Chapter 6, I summarize the implications of the integrated quantitative and qualitative findings, report on the affordances and limitations of this study and establish goals for future research.

Chapter 6: Conclusions, Limitations, Affordances, and Implications for Future Research

In this chapter, I begin by summarizing the quantitative and qualitative findings to connect to existing research, point to nuances in my conclusions, and discuss the implications of this study. The study implications section leads to a discussion on the limitations and affordances of the study. I conclude the chapter by identifying goals for future research.

Overview of Study

This explanatory sequential mixed methods study was part of a larger multistage mixed methods design (Creswell, 2015) that was developed to investigate the sociohistorical, intrapersonal, and institutional factors that contribute to the persistence and success of undergraduates enrolled in remedial mathematics courses at a four-year university. The first stage of the design incorporated qualitative interview and observational data collection and analysis. The qualitative findings, coupled with Martin's (2000) Mathematics Socialization and Identity Framework, were used to develop the survey instrument I tested during the second phase of the design. The two final stages of this multistage mixed methods design were the focus of this dissertation.

As discussed in detail in Chapter 3, this study began with quantitative data collection, using a Likert-type instrument. Departmental data was also collected from the entire remedial mathematics student population at the university under study ($n=486$). Then, I ran a quantitative analysis of the sample data ($n=316$) which included descriptive statistics, correlation analysis, factor analysis, logistic regression, and extreme case analysis. Extreme case selection was used to select the participants for interviews.

Interviews were conducted, transcribed verbatim, thematically coded and analyzed before both streams of data were integrated into a joint display. The joint display informed the cross-case analysis and broader persistence findings. The quantitative success data was then analyzed using descriptive and inferential statistics, in light of the persistence findings.

Quantitative findings

The Racialized Experiences of African Americans

Corequisite enrollment. The participants' high rates of persistence (92%) and success (68.4%) could partially be explained by enrollment in corequisite versus emporium remedial mathematics courses. Participants enrolled in a corequisite course were nearly 12 times more likely to succeed than their peers in the emporium courses ($p<.01$). This finding adds to existing evidence about the positive effect that accelerated remedial mathematics courses have on persistence and success in remedial mathematics (Carnegie Foundation for the Advancement of Teaching, 2015; Hern & Snell, 2014; Palmer, 2016; Tennessee Board of Regents, 2016). However, African American and minority students were overrepresented in the emporium courses when compared with the corequisite population (51.2% African American versus 37.2% in corequisite courses, and 80.3% minority versus 60.6% in corequisite courses) and when compared with the university population (51.2% African American versus 12.9% university-wide and 80.3% minority versus 43% university-wide; OIRPA).

Advanced high school mathematics course-taking. The institution's non-randomized sorting of students into the emporium or corequisite courses was based upon institutional markers (placement test scores) which were influenced by sociohistorical factors; primarily, advanced high school mathematics course-taking which, in turn, was related to participants' race and parental education. There was a correlation between advanced high school mathematics course taking and placement into corequisite remedial mathematics courses at this university, suggesting that African American students' racialized experiences in K-12 mathematics (Oakes, 1990; Secada, 1992; Tate, 1997) not only determined their placement into an emporium remedial mathematics course at this university but also affected their persistence and success in their remedial mathematics courses. For the full sample, participants who took pre-calculus, calculus or statistics in high school were nearly nine times more likely to persist than those who did not ($p<.01$). For the emporium group, participants who took these advanced mathematics courses in high school were roughly six times more likely to persist than their peers who did not ($p=.017$).

As discussed in Chapter 4, being African American was a predictor of persistence indirectly. The logit model for persistence indicated that African American students were 2.7 times more likely to fail to meet their remedial mathematics requirements than their non-African American peers ($p = .039$). However, once the predictor *last K-12 mathematics course* was added to the model, African American identity was no longer a statistically significant predictor of persistence ($p =.096$). This relationship between African American identity, advanced mathematics course taking, and remedial mathematics placement adds to existing research. In particular, NCES (2005) reported that African American undergraduates were more likely to be first generation college students and more likely to be enrolled in remedial courses in college, and Harwell et al. (2014) found that African American (36%) and Hispanic (26.1%) students were more likely to place into remedial mathematics than their White peers (10%). However, the non-significance of ethnicity as a predictor of persistence in remedial mathematics is consistent with Mireles et al. (2014) whose reported "no statistically significant effects of ethnicity on course withdrawal" (p. 29) after implementing the FOCUS intervention described previously in Chapter 2. However, the non-significance of ethnicity as a predictor of persistence in remedial mathematics contradict Wolfle (2012) who identified ethnicity and age as significant predictors of remedial mathematics students' success in their first college-level mathematics in a community college setting.

First-generation college students. For the full sample, participants who had a primary parent/guardian with at least some college education were about 4.3 times more likely to persist than those who had a primary parent/guardian with no college education (p=.01). Although not statistically significant (p=.056 and .053, respectively), students enrolled in the emporium courses whose parents had at least some college education were still 3.3 times more likely to persist and 2.5 times more likely to succeed than students whose parents had no college education. These findings are also consistent with previous results. In particular, Nunez and Cuccaro-Alamin (1998), Ishitani (2003), and NCES (2005) all show that first-generation college students are more likely to be minorities and less likely to take advanced courses in high school. This puts them at greater risk for placement into remedial mathematics and attrition.

Motivations, beliefs, perceptions and academic behaviors. Overall, the participants' high degree of intrinsic and extrinsic motivation, their more positive beliefs about the university climate, their peers and their remedial mathematics teachers, their views that success in mathematics was important to their persistence and success. Additionally, their engagement in productive academic behaviors also partially explained their high rates of persistence. These findings are consistent with Martin (2000), Zienteck et al. (2013), and Zienteck et al. (2014) who find [briefly. The findings on these participants' positive perceptions of peers and the university climate are well-aligned with Tinto's work in college settings (1975, 1987, 1993, and 2007) but contradict Martin's findings (2000) in the high school setting. In particular, that my participants' tended to disagree that they experienced differential treatment in mathematics-related contexts due to their racial/ethnic identity contradicted Martin's (2000) qualitative results. However, when the data was disaggregated, Latinx and African American participants and participants in emporium courses had significantly higher mean perceptions of differential treatment in mathematics related contexts (both $p<.01$).

Gender

For the full sample, the odds of persistence were roughly 4.7 times greater for females than males ($p=.012$), and for the emporium group, the odds of persistence were approximately 3.9 times greater for females than males ($p=.039$). For both the full sample and the emporium group, females were three times more likely to succeed than their male peers (both $p<.01$). These gender-related findings are consistent with those reported by Davidson and Petrosko (2015) who found that being female was a significant predictor of persistence in remedial mathematics in a community college setting and to those of Mireles et al. (2014) who reported that females were more likely to persist in remedial mathematics at 4-year colleges.

Perceptions of Remedial Mathematics Teacher

For both the full sample and the emporium group, the odds of persistence nearly doubled for every one standard deviation increase in a participants' perceptions of their remedial mathematics teacher, when holding all other predictors constant. While less significant, the odds of success were still 1.4 times higher for every one standard deviation increase in a participant's perceptions of their remedial mathematics teacher for the full sample (p=.059) and 1.5 times higher for every one standard deviation increase in a participant's perceptions of their remedial mathematics teacher for the emporium group (p=.05). These quantitative perceptions of teacher findings add to our understanding of the importance role that students' perceptions of teachers play in predicting persistence and success in remedial mathematics (Hall & Pontoon, 2005; Solomon, 2007; Wicker, 2002)

Academic Major

Based on previous studies, an unexpected finding was that the participants' academic major (r=-.147, p<.01) seemed to influence their mathematics success, although it was not a significant predictor (p=.378). Specifically, non-STEM and Business majors enrolled in remedial mathematics were more likely to succeed in their subsequent college-level mathematics courses than their peers who were STEM majors. Davidson and Petrosko (2015) reported differential rates of persistence in remedial mathematics at technical and community colleges based on academic major. However, they did not disaggregate their data to individually examine differences in persistence and success in remedial mathematics based upon whether the participants were STEM or non-STEM majors.

Qualitative findings

The Experiences of African Americans in Emporium Courses

Academic isolation. The qualitative conclusions provided by the interview data of the five African American perception of teacher cases revealed several institutional and classroom factors that impacted emporium participants' experiences, beliefs, perceptions, motivation, and ultimately, their persistence and success. The participants' responses to questions regarding their remedial mathematics teachers reflected their negative perceptions of their emporium course. All five of the interview participants had negative commentary regarding their emporium courses' online instructional format, the lack of teacher-led instruction, the lack of engagement in their mathematics, and the lack of collaboration with peers.

The fact that the emporium courses were online clearly constrained student-teacher interactions, and this shaped the participants' evaluations of their emporium instructors. Participants with higher perceptions of teacher scores were more explicit about this relationship and more clearly attributed their challenges to the emporium course structure than their teacher, while participants with a lower extreme perception of teacher scores attributed their problems in their emporium courses to teacher behaviors. The relationship between the participant's negative perceptions of their remedial mathematics course, the teacher's instructional practices, and persistence and success in remedial mathematics aligns with Solomon's (2007) research on identities of participation and exclusion in STEM. Solomon found that identities of exclusion develop when undergraduates feel isolated by the mathematics classroom environment and instructor's pedagogical practices. It also is consistent with Acevedo-Gil et al.'s (2015) finding that students in remedial mathematics encountered validation and invalidation through curricular practices in the community college setting. Specifically, they reported that invalidating events "had a negative effect on the educational experiences of participants, lowering educational aspirations, academic self-confidence, and self-efficacy" (p. 108).

Marginalization from STEM. The three STEM majors, Alana, Ellie, and Sparrow had more negative socio-academic experiences at the university than their non-STEM peers, Edna and Marcus. As they explained, this was largely because placement into remedial mathematics prevented STEM majors from either declaring their major or pursuing their major-specific coursework. This negatively impacted their beliefs about their mathematics abilities, their perceptions of their peers, and their degree of social and academic integration. Alana's placement into remedial mathematics conflicted with her academic and STEM identities and caused her to question the validity of negative dominant narratives about minority achievement, despite her high performance in high school and outside of mathematics at the university. Ellie's placement into remedial mathematics conflicted with her ethnic and STEM identities, causing her to isolate herself even further. Both of these identity conflicts reduced Alana and Ellie's motivation to persist in their remedial mathematics classes and STEM. This finding expands on Larnell, Boston, & Bragelman's (2014) work on stereotype threats African American students experience in university remedial mathematics contexts and the ways they manage and respond to those perceived threats (Larnell, Boston, & Bragelman, 2014), particularly in regards to whether the undergraduates are STEM or non-STEM majors.

Alana's socio-economic factors, such as not having the financial means to live on campus and having heavy work and family responsibilities, compounded the adverse effects of her remedial course placement. These factors also further degraded Alana and Sparrow's beliefs, perceptions, and motivation to persist in mathematics. While emporium mathematics placement negatively impacted Alana and Ellie's identities and diverted them out of STEM, Sparrow's high self-efficacy in computer science preserved his STEM identity. His emporium mathematics placement caused him to consider transferring to an alternative university, but he did not report any desire to divert out of STEM. This finding is consistent with Espinoza (2008) who reported gender differences for academic self-concept development among undergraduate minorities pursuing STEM. A key difference was that positive academic self-expectations and the value for group work were significant predictors of academic self-concept for minority females exclusively, while STEM research opportunities and satisfaction with science and math coursework predicted male participants' academic self-concept.

Agency

The case study participants who persisted through their emporium courses leveraged a variety of intrapersonal, academic and social assets such as their financial motivation, the socio-academic support of peers, their parents' positive perceptions of their academic abilities, academic advisors and university academic supports, in ways that supported their persistence when they faced challenges in their emporium classes. In contrast, those who did not persist faced additional barriers that prevented them from accessing and leveraging such assets. In particular, Alana and Sparrow did not have the financial means to live on campus. They resided off campus with their parent(s) and siblings and worked at least 30 hours a week during the academic year to pay for college and support their families. Their work responsibilities, family responsibilities, and off-campus housing limited their time on campus, reducing their access to socio-academic supports leveraged by their peers who persisted. Nonetheless, all five of the participants were actively engaged in agentive behaviors focused on their undergraduate degree attainment. This finding is consistent with Martin (2000) who reported that African

American high school mathematics students, their parents and their community members, "were not passive recipients of [their] experiences. They were able to exercise a great deal of agency in the face of [sociocultural] forces, actively constructing meanings for mathematics learning and mathematics knowledge, and acting on those meanings accordingly (p. 118).

Integrated Findings

The qualitative and quantitative data were integrated using extreme case analysis and a joint display. As reported in the qualitative findings, the extreme case analysis helped to explain the relationship between the participants' perceptions of their remedial mathematics teacher and their persistence in remedial mathematics. Through the joint display of the integrated data, I also identified areas of congruence and discrepancy that existed among the quantitative and qualitative data. For this dissertation, I will only report on the discrepancies using simplified joint displays of the integrated data for three cases: Ellie, Marcus, and Alana (Table 3).

TABLE 3
JOINT DISPLAY OF QUANTITATIVE AND QUALITATIVE DATA DISCREPANCIES

Case	**Course**	**Perception of teacher score (β=1.809, *p*=.03)**	**Persisted**
Ellie (STEM major) *Congruent*	corequisite ***Discrepant***	within 1.5 s.d. of μ ***Discrepant*** **Negative perceptions of the emporium learning environment**: *I would just sit there for three hours, and I was so inclined to procrastinate and just get my mind off math because you're just sitting there not doing anything. Like, there's no, there's no instruction. There's nothing being, like, given back to you I guess, so you're just kind of sitting there. You're on your laptop. You can just swipe over and watch a YouTube video, get on Netflix, that kind of stuff. Um, and it just, it's very hard to stay focused on math and getting to that direction where you need to be for your major.* **Academic Isolation***: I didn't really talk to anyone in 003, mostly because I just, I didn't like the fact that I was in 003.* **Marginalization from STEM**: *When people would ask me what my major was, and I would say comp sci, and they would say, "Oh, which, um, comp sci class are you in?" And I would just kind of be like, "Uh, I'm not in any because I can't because of my math class." And people would be like, "Why?" And then I have to explain that I'm in 003, and then I, not, like, I would get kind of like a negative reaction, but I just didn't like having to tell people. It just didn't feel, it felt kind of like I was failing.*	Yes ***Discrepant*** *I ended up failing the class because I've never been in a math class where you're not actually taught, especially a three-hour math class where you just sit there on the computer. I don't really like computer math.*

TABLE 3 (CONTINUED)

Case	**Course**	**Perception of teacher score (β=1.809, *p*=.03)**	**Persisted**
Marcus (non-STEM major) *Congruent*	emporium *Congruent*	μ-2.5 s.d. ***Discrepant*** **Negative perceptions of the emporium learning environment***: I didn't really like [the emporium class] at first because I felt like I should've been like way more ahead than taking [the emporium] class. I don't know. It just felt weird honestly, to me and it wasn't like a teacher writing on a board. It was just like, us on a computer, just learning ourselves in our own little world and space and bubble. That kind of like, makes me procrastinate in actually getting help.* **High self-efficacy***: There's people who've always had, like, high expectations of me. When I know I need to get something done, I just, you know, get it done. It's sort of, like, how I've been raised. If I have to take it if that's the requirement.* **Leveraging socio-academic supports***: I like uh, my professor, he's also my advisor. He's a pretty cool person, um, very open. So yeah, he's, he's helped me a lot. My advisor pointed me to [OMSE]. He also pointed me to LAS, which is the Learning Assistant Services. OMSE] is like for multicultural um, studying and tutoring sessions that they have here. LAS more so helps you, like, I guess, improve as a student. So, instead of tutor[ing], they will tell you, like, what you need to do. Like, how you need to study.*	Yes *Congruent*

TABLE 3 (CONTINUED)

Case	Course	Perception of teacher score (β=1.809, *p*=.03)	Persisted
Alana (non-STEM major) ***Discrepant*** *When my major read on my sheet, like, Letters and Sciences, I'm like, "Why am I in Letters and Sciences? I've picked Biology as my major going in when I did the application," and then, I also was thinking, since I got into the honors college that maybe it would push me to priority to like... direct admit into the major. But, I guess not. I couldn't do it for Biology yet, only because like I still haven't even taken a natural lab. Like, I have to take, I have to take Pre-calculus, and then I have to take Calculus because I can't take, um, the lab, which is like 160 and 161…until I'm taking, like, Calculus. Calculus was a prerequisite for that lab, and that's one of the gateways that I have to do.*	emporium *Congruent*	*μ-3.0 s.d.* *Congruent*	No. *Congruent*

Ellie's Non-Persistence

Ellie was correctly identified as a STEM major in the quantitative data, but she was incorrectly identified as a persister in a corequisite remedial mathematics course. Through Ellie's interview, it was clear that she not only placed into the emporium course initially but that she remained in the class and failed it. Ellie's misidentification as a persister in the quantitative data was based upon her placement exam retake which she passed in September, not the fact that she failed the emporium course she remained in for the entire fall semester. This finding is significant because it demonstrates two things. First, the qualitative data collection and analysis pointed to the potential for misclassifications of a participant's persistence in the quantitative data set. While one could argue that Ellie fulfilled her remedial requirement by passing her placement exam retake, this first finding also implies a second. The adverse effects of the emporium structure could override the participants' ability to persist, regardless of their mathematics proficiency.

As stated previously, Ellie was the mean perception of teacher case, but she did not persist through her emporium coursework. This finding points to a discrepancy in the predictability of the perception of teacher factor. However, as previously discussed in Chapter 5 and above, Ellie had extremely negative views of her emporium course placement. Part of this was because of her academic isolation based on the emporium classroom environment and the conflict between her academic and STEM identity and her placement in remedial mathematics which led her to isolate herself from her peers in remedial mathematics. Ellie was also marginalized from STEM; because of her remedial mathematics course placement, she was prevented from academically integrating with her computer science peers, and this impacted her degree of social integration with them as well. Again, this finding is aligned with and contributes to existing research on identities of participation and exclusion in STEM (Solomon, 2007).

Marcus' Persistence

As discussed in Chapter 5 and above, Marcus had an extreme perception of teacher score (μ-2.5 s.d.) and was not predicted to persist. He did. In his interview, Marcus attributed his ability to persist to a variety of intrapersonal, family, and institutional factors. Even though Marcus did have negative perceptions of the learning environment and his remedial mathematics teacher's ability to support his mathematics achievement, Marcus drew on several helpful resources that helped him to persist. He had high self-efficacy based upon his high school academic experiences and the positive perceptions his parents and others had for his academic abilities: "There's people who've always had, like, high expectations of me. When I know I need to get something done, I just, you know, get it done. It's sort of, like, how I've been raised." Marcus also took full advantage of his positive relationship with his advisor and followed through with obtaining academic supports based on his advisor's recommendation. The discrepancy between Marcus' predicted persistence and his ability to persist helped me identify important factors not accounted for among the survey items: parents, family and community members' perceptions of the participants' academic abilities, the strength of the relationship between a participant and their academic advisor, and the participants' selected academic supports and the frequency in which they use them.

Alana's Non-STEM Status

Finally, it was clear in Alana's interview that she was identified as a non-STEM major in the quantitative data because her remedial mathematics placement prevented her from being admitted into the program. This discrepancy between Alana's listed major and her intended major point to issues in what is tracked in the departmental mathematics data and to limitations in the quantitative findings. Without the interview data, I would not have known that Alana intended to major in Biology and diverted out of STEM. Fifty-six percent of the participants who did not persist were in one of two colleges, the Academic Achievement Program, and Letters and Sciences. It is quite likely that within these two colleges there were additional participants who intended to declare or pursue STEM but were unable to do so due to their remedial course placement. This finding may help to explain why *Academic Major* was significantly correlated with success in the emporium courses but was not a significant predictor of success and points to a need for additional data in the departmental data sets that accounts for the students intended majors upon acceptance into the university.

Implications

State Level Policy Recommendations

The state in which the participating university is located mandates that all college students earn at least three credits of mathematics to graduate with their bachelor's degree. This is called the Fundamental Mathematics Studies requirement. The state requires undergraduates to have a high school diploma or high school equivalency degree but gives room for institutions to determine eligibility through evidence, such as testing, previous formal education, examinations, and competencies gained through practical experience, maturity, or other appropriate criteria. It also allows higher education institutions to award credit hours for prior learning or the demonstration of skills and knowledge in specific areas, based on standardized and institutional examination scores (such as Advanced

Placement coursework). The state prevents higher education institutions from including credit awarded for remedial education for graduation credit requirements.

First, in order to improve K-12 and college-level outcomes for minorities in mathematics, the state must commit to ending the structural racism that is deeply embedded in its educational system and make significant efforts to improve equity in K-12 mathematics education. The emporium courses were 86% of minority students who were less likely to have taken advanced mathematics courses in high school. Recall that participants who took pre-calculus, calculus or statistics in high school were nearly nine times more likely to persist than those who did not ($p<.01$) and this was the most significant demographic predictor of persistence. Thus, the state needs to increase efforts to recruit, train and retain highly qualified secondary mathematics teachers in high minority schools and to ensure that all state high schools provide students with advanced mathematics courses. We also know that having the advanced classes at the school does not ensure minority access or engagement in those courses (Wilhelm, Minter, and Jackson, 2017). For this, significant efforts need to be made at the state level to increase cultural competency and end tracking in mathematics.

Second, the state needs to articulate mathematics benchmarks that meet the college level mathematics prerequisite. Currently, there is no such standard. While community colleges across the state exempt students from mathematics placement tests based on benchmark PARCC, SAT, and ACT scores or grades in Algebra II or more advanced math courses in high school, this university does not provide these exemptions. Thus, placement into remedial mathematics in this state can differ based on the institution you attend, and this lack of transparency is disproportionately affecting minority students. Related, the state should develop a multiple measures approach to guide students' placement into college/university mathematics courses. One of the most significant demographic predictors of remedial mathematics persistence and success was the participants' last high school mathematics course. Thus, 'last high school mathematics course' should be included as part of the multiple measures approach.

Additional factors that should be taken into account in any multiple measures approach are students' intrapersonal factors. For example, students who demonstrated a strong desire for academic and social integration were less likely to have positive experiences in the emporium remedial mathematics courses and less likely to persist through them. In addition, STEM majors, or those who intend to major in STEM, were more likely to be "cooled out" of STEM when faced with a remedial mathematics barrier, particularly the emporium courses which had the potential to push course-taking for their majors back a year or more. Thus, intrapersonal factors such as the student's intended major and the degree they are motivated by their level of academic and social integration should be taken into consideration when determining undergraduate mathematics course placements. The state has the power to develop guidelines that holistically examine students to ensure they are placed in the most supportive mathematics learning environments.

Third, the state should invest in funds to provide scholarships and grants to support minorities in STEM in urban and high minority schools. As Edna noted in her interview, her white peers who placed directly into Business Calculus had access to Calculus in high school, and they also had access to summer camps and STEM programs that she did not. There are several Saturday schools, STEM programs, and summer programs that exist across the state for economically advantaged students. These should be equitably distributed.

Finally, the state should provide financial support for curricular alignment across K-12 and college level mathematics. Students who have taken Pre-calculus, Calculus, AP Calculus and AP Statistics in high school should not place into a remedial mathematics course. While some of this may resolve through a statewide benchmark that outlines college-level mathematics readiness, there is an issue with curricular alignment as well.

Institutional Level Policy Recommendations

The participants in corequisite courses at this university had a nearly 100% persistence rate and 88% success rate. However, it is clear that students of color who attend this university experience differential opportunities to learn higher level mathematics in high school (U.S. Department of Education for Civil Rights, 2014) and this affects their overrepresentation in remedial mathematics, particularly students in the emporium mathematics courses, who had significantly lower persistence (81%) and success rates (39%). Based on the statistical outcomes, these lower persistence and success rates were due to the lack of advanced mathematics coursework in high school, but also the emporium course's online structure and the associated teacher practices, classroom environment, and the teacher-student relationship. These academically isolating experiences were exclusive to the emporium course because of the course structure.

One solution, at the university level, is to transition to corequisite only remedial mathematics courses and to eliminate the emporium courses. I understand that there are costs associated with the mathematics computer lab equipment and curricula used in the emporium model, and the university may not want to discard these resources. This cost concern could be remedied by using the emporium resources to provide additional supports for corequisite students in need of more significant academic support, which has been found to increase remedial mathematics outcomes (Wladis et al., 2014). By eliminating the fully online emporium courses, all undergraduates who place into remedial mathematics at the university will have the benefit of experiencing mathematics learning in an environment that is arguably more supportive of their socio-academic learning needs.

Second, in addition to the state level recommendation for implementing multiple means of measuring students' mathematics backgrounds and learning needs to provide them with the most supportive mathematics learning environments, the institution should also re-examine the placement test for university mathematics. The majority of participants in this study had four or more years of high school mathematics but did not prepare for the placement test or said they didn't know how to prepare for it. The majority of them did not understand the implications of not studying for their placement exams, and three of the participants in the case studies did not have time allocated to study for and complete their placement tests. Since this university's placement test was (and still is) entirely online, students with greater cultural capital and economic status were going to be (and will continue to be) more likely to solicit resources like time, tutors, and peers to support their success on their mathematics placement tests. It's difficult to argue that the placement test is an accurate measure of an undergraduate's mathematics capabilities. As stated in Chapter 2, regression discontinuity studies have not uncovered better outcomes for students who receive remedial education compared with those students who do not (Bailey et al., 2013) and Johnson (2007) discovered that the Intermediate Algebra skills taught at one public, liberal arts, university were unnecessary for 3 of the four college mathematics courses it preceded. If 86% of the corequisite participants were successful in their subsequent college-level mathematics course, were the corequisite participants really in need of five weeks of mathematics remediation, or did the placement policies and test misrepresent the participants' ability to perform in college-level mathematics? Based on research on the effectiveness of remediation, I would argue the latter is the case.

Third, this study demonstrates the need for targeted financial, affective and socio-academic interventions to support STEM majors who place into remedial mathematics. To do this, the university needs to identify who those students are accurately, and this means adapting departmental data to include the intended majors of students accepted into the university. It also means that STEM colleges at this university need to carefully consider the racialized effects of their exclusionary admittance and course-taking policies. By excluding minorities from STEM through these policies, they are perpetuating the cycle of minority underrepresentation in STEM and frankly, the systemic racism exhibited in STEM degree, career and salary attainment. Instead of marginalizing minority students from STEM because of a mathematics placement test or mathematics high school experiences, perhaps STEM colleges should evaluate the whole student, allow admittance into STEM majors and coursework, and provide on-demand mathematics supports to those who need it to complete their STEM coursework and attain their STEM degrees. Potocka (2010) reported that on-demand mathematics supports led to improved outcomes for remedial mathematics students. Finally, the university needs to consider that students in remedial mathematics are at higher risk of dropout than their peers. Thus, these students have a greater need for financial supports that enable them to live on campus and have reduced workloads so that they can take advantage of available institutional socio-academic supports.

Affordances and Limitations

Limitations

There were a number of limitations to this study that pertained to a variety of factors, including the nature of self-reported data, the extreme case selection process, discrepancies between the mathematics department's definition of persistence and the one used for the study, and the failure to capture socioeconomic barriers on the survey. The survey and interview data was entirely self-reported, and self-reports are generally accepted as reliable, no data was collected from instructors, family members or peers to check the validity and reliability of the self-reported data. In addition to relying on self-reported data, the extreme case selection was skewed because all perception of teacher cases were extreme negative cases. This was due to a lack of extreme positive perception of teacher cases in the data set. Although the extreme case selection of extreme perception of teacher cases did provide insight into the nuanced experiences of remedial mathematics students in STEM and the barriers and supports that impacted the selected participants' persistence and success, the inability to identify and select an extreme positive perception of teacher case limited my ability to examine any potential counternarratives.

Furthermore, the mathematics department coded participants as persisters based upon a different set of criteria than was used for this study. The quantitative data was collected from the mathematics department and the survey instrument. As discussed above, the mathematics departmental data indicated Ellie persisted through a corequisite remedial mathematics course. Through Ellie's interview, it was clear that she not only placed into the emporium course initially but that she remained in the class and failed it. Ellie's identification as a persister in the departmental data was based upon her placement exam retake which she passed in September, despite the fact that she failed the emporium course she remained in for the entire fall semester. This identified discrepancy indicated there were differences between the university's definition of persistence (and how students were coded in departmental data) and the definition of persistence used in this study. It points out that there may be additional misclassifications of persistence (in relation to this study's definition) in the mathematics department's data set. Related, Alana was identified as a non-STEM major in the mathematics department's data set because her remedial mathematics placement prevented her from being admitted into the Biology program. This discrepancy points to issues in what is tracked by the mathematics department and to further limitations in the quantitative findings.

Finally, there were a number of factors that appeared to play a significant role in the participants' persistence that were not captured by the survey. Marcus had an extreme perception of teacher score (μ-2.5 s.d.) and was not predicted to persist, but he did. This discrepancy helped me identify factors not accounted for among the survey items: parents, family and community members' perceptions of the participants' academic abilities, the strength of the relationship between a participant and their academic advisor, and the participants' selected academic supports and the frequency in which they use them. Sparrow and Alana's interview data also pointed to the survey's inability to capture socioeconomic barriers that prevented the participants from taking advantage of available university socio-academic supports and impacted their persistence. These included off-campus housing, commutes, work hours and additional family responsibilities.

Affordances

If this study were not an explanatory sequential mixed methods study, the study limitations outlined above would likely not have been identified. The quantitative research methods allowed me to examine general patterns and relationships between sociohistorical, intrapersonal, and institutional factors and the participants' persistence and success. By reviewing the integrated quantitative and qualitative data using extreme case analysis, I was able to explain the quantitative findings. By examining the integrated data in the joint display, I was able to identify discrepancies between them. Each strand of research did complement the other and certainly provided me with, "a better understanding of the problem than either form of data alone" (Creswell, 2015, p. 2).

While it makes sense that the university would identify a placement test retake score as persistence for their purposes of mathematics course placement, my differing definition, and the integrated data demonstrated that the adverse effects of the emporium structure could override a participant's ability to persist through their emporium course, regardless of their mathematics proficiency. Also, without the explanatory sequential mixed methods design, I would not be able to identify the limitations of the survey items, nor would I have known that Alana intended to major in Biology and diverted out of STEM. These findings led to implications for improving the survey instrument and for better data collection and management in future studies. Finally, by employing the explanatory sequential mixed methods design, I uncovered nuances that supported and prevented participants from persisting in the emporium courses that would not have been possible through one method alone.

Goals for Future Research

Recent reform efforts in remedial mathematics and research on the impact these reforms have on student retention and college completion, provide evidence that there is a need for ongoing research on remedial mathematics. This call for further research is particularly valid for studies that attend to programmatic details, the diversity of students who place into remedial mathematics, and what they perceive as barriers or supports to their success. While there is a growing body of quantitative research on the impact of remedial mathematics and factors associated with persistence and success, more research is needed that incorporates complex sociocultural frameworks and complementary research methods.

There are several goals for future research tied to this call. First, I would suggest integrating the socioeconomic, family/community and socio-academic factors discussed above to improve the accuracy of predicting persistence and success in remedial mathematics. Second, I would suggest reviewing institutional data to see if preliminary data on general colleges, such as the AAP and Letters and Sciences at this university, is captured and can help to identify whether they contain students intended on majoring in STEM who were prevented from declaring. If this is the case, I would suggest integrating this information into the data set and running quantitative analysis to determine whether there are discrepancies in the findings. Third, I would recommend the integration of this analytic framework into studies on remedial mathematics students at other 2-year and 4-year colleges and universities, to identify which findings hold and which results are specific to this university's contexts.

APPENDICES

APPENDIX A: SURVEY

How important are each of the following to you in achieving your educational and career goals?

Use an x to mark your response for each part:

	Not At All Important	Slightly Important	Moderately Important	Very Important	Extremely Important
(a) Financial aid					
(b) Emotional/motivational support of family members					
(c) Emotional/motivational support from math teacher(s)					
(d) Emotional/motivational support from peers					
(e) Access to a mentor in your field of interest that you can identify with					
(f) Instructional support from teachers					
(g) Instructional support from peers					
(h) How your classmates make you feel about your career choice					
(i)How your teachers make you feel about your career choice					
(j) How your friends make you feel about your career choice					
(l) Grades (in mathematics)					
(m) Guarantee of employment after completion of program					
(n) Relationships to community or family members who are professionals in your area of interest					
(o) Classroom experiences (in general)					
(p) Classroom experiences (in mathematics)					
(q) Early mentoring experiences in your field of interest					
(r) Your work ethic					
(s) Your desire to obtain your education					
(t) Your racial/ethnic identity					

Please rate each statement below by circling a number between 1 and 5 where:

1: Strongly Disagree 2: Somewhat Disagree 3. Neither Agree nor Disagree 4: Somewhat Agree 5: Strongly Agree

I am a top student in my math class.	1	2	3	4	5
I am good at mathematics.	1	2	3	4	5
My mathematics class challenges me.	1	2	3	4	5
I want to take more mathematics classes.	1	2	3	4	5
I have a sense of belonging in my mathematics class	1	2	3	4	5
I like my mathematics class.	1	2	3	4	5
I had positive math experiences in middle/high school	1	2	3	4	5
I have a sense of belonging at school.	1	2	3	4	5
My friends would say I'm a good student.	1	2	3	4	5
My teacher makes me feel welcome in math	1	2	3	4	5
My teacher supports my conceptual understanding in math class	1	2	3	4	5
I know my teacher believes I can succeed in math	1	2	3	4	5
My teacher motivates me to work through challenges in math	1	2	3	4	5
My teacher helps me make sense of math	1	2	3	4	5
My math teacher expects me to succeed in math	1	2	3	4	5
My mathematics teacher understands/knows my learning needs	1	2	3	4	5
I am confident I can meet my math teacher's expectations	1	2	3	4	5
My classmates and I have similar beliefs about our math class	1	2	3	4	5
My classmates and I have similar beliefs about school	1	2	3	4	5
My classmates and I have the same beliefs about mathematics	1	2	3	4	5
I am comfortable asking questions in math class	1	2	3	4	5
My friends would say I'm good at math	1	2	3	4	5
I have positive relationships with classmates in math	1	2	3	4	5
I have positive relationships with classmates outside of math class	1	2	3	4	5
I have math support available outside of math class	1	2	3	4	5
I feel comfortable asking for and/or using school resources (tutors/labs/study hall) to help me succeed in mathematics	1	2	3	4	5
In math, I have been treated differently because of my race/ethnicity	1	2	3	4	5
My success in math is important to my family	` 1	2	3	4	5
Success in math is important to my peers	1	2	3	4	5
My math success is important for attaining my career goals.	1	2	3	4	5
Math is relevant to my future career	1	2	3	4	5
I can apply what I learn in my math class to my life	1	2	3	4	5
Math helps me understand the world around me	1	2	3	4	5
My success in math is important to me	1	2	3	4	5
Attending my math classes is a priority	1	2	3	4	5
I always complete my math homework	1	2	3	4	5
If I have questions about math, I make a point to seek answers by meeting with my teacher/TA, tutors, or classmates	1	2	3	4	5
I work through challenges in my mathematics classrooms and do not give up	1	2	3	4	5

Do you receive needs based financial aid (such as a Pell Grant)? Yes No

Please mark the highest level of education attained by your primary guardian or parent. MARK ONE.

___Less than high school

___GED (high school equivalency)

___High school diploma

___ Some college

___ 2-year college or associate degree

___College degree (bachelor's)

___Graduate education or degree

Is English your native language? Yes No

What high school did you graduate from?____

What city/state is the school in?

____

How much mathematics (in years) did you take in high school?

____

What was the last K-12 mathematics course you took prior to taking the University's math placement exam?____

Did you study for your first mathematics placement exam? Yes No

Did you feel your high school math courses prepared you for the math placement exam? Yes No

Did you transfer from a community college? Yes No

Thank you for your time and effort for completing this survey.

APPENDIX B: GUIDING INTERVIEW QUESTIONS

Note: The questions in this protocol are meant to serve as guides. Questions will be modified in response to field data and participant responses. For that reason, the questions below are representative, but not all-inclusive, of possible interview questions. They are adapted from interview questions designed by Danny Martin (2000) as described in *Mathematics Success and Failure among African-American Youth.*

1. How would you describe yourself as a person? A student? A math student?
2. Can you describe what it's like to be a _student in the _program here on campus?
3. How do you describe your mathematics experiences this year?
4. What do you think about your current mathematics teachers, classrooms, and classes?
5. What challenges did/do you face relating to your mathematics class (es)?
6. What resources (friends, peers, teachers, tutoring, LAS, etc) did/do you find most helpful for your mathematics success?
7. How could your interest and/or experiences in your mathematics class (es) be improved upon?

APPENDIX C: RQ, SURVEY ITEM & INTERVIEW ALIGNMENT

"How do sociohistorical, intrapersonal, and institutional factors relate to the persistence and success of undergraduates who are enrolled in remedial mathematics classes at a university?"	All survey and interview data
a. What personal goals and motivations are important to undergraduates enrolled in developmental mathematics courses?	Section I (goals and motivations): Financial aid Emotional/motivational support of family members Emotional/motivational support from math teacher(s) Emotional/motivational support from peers Access to a mentor in your field of interest that you can identify with Instructional support from teachers Instructional support from peers How your classmates make you feel about your career choice How your teachers make you feel about your career choice How your friends make you feel about your career choice Grades (in mathematics) Guarantee of employment after completion of program

	Relationships to community or family members who are professionals in your area of interest Classroom experiences (in general) Classroom experiences (in mathematics) Early mentoring experiences in your field of interest Your work ethic Your desire to obtain your education Your racial/ethnic identity
b. What do they believe about mathematics and their mathematics abilities?	Section II: I am a top student in my math class. I am good at mathematics. My mathematics class challenges me. I want to take more mathematics classes. I have a sense of belonging in my mathematics class I like my mathematics class. I had positive math experiences in middle/high school I am confident I can meet my math teacher's expectations
c. What are their perceptions of the school climate, their peers and teachers in math related contexts?	Section III: I have a sense of belonging at school. My friends would say I'm a good student. My teacher makes me feel welcome in math class My teacher supports my conceptual understanding in math class

	I know my teacher believes I can succeed in math My teacher motivates me to work through challenges in math My teacher helps me make sense of math My math teacher expects me to succeed in math My mathematics teacher understands/knows my learning needs My classmates and I have similar beliefs about our math class My classmates and I have similar beliefs about school My classmates and I have the same beliefs about mathematics I am comfortable asking questions in math class My friends would say I'm good at math I have positive relationships with classmates in math I have positive relationships with classmates outside of math class I have math support available outside of math class I feel comfortable asking for and/or using tutors/labs/study hall to help me succeed in mathematics In math, I have been treated differently because of my race/ethnicity My success in math is important to my family

	Success in math is important to my peers
d. What motivates their learning of mathematics?	Section IV: My math success is important for attaining my career goals. Math is relevant to my future career I can apply what I learn in my math class to my life Math helps me understand the world around me My success in math is important to me
e. How do they express agency in response to perceived opportunities and challenges related to their developmental mathematics courses and requirements?	Section V: I work through challenges in my mathematics classrooms and do not give up. Attending my math classes is a priority I always complete my math homework If I have questions about math, I make a point to seek answers by meeting with my teacher/TA, tutors, or classmates

APPENDIX D: OBSERVATION PROTOCOL

Observer ___________Date of Observation: _______________________ Page ___ of _____

School: _______________ Course: ______________ Instructor:________________
Session Date: ____________
1. Start of Class (Min:Sec): _______________ 2. End of Class (Min:Sec): _____________

	Observations:	**Activity ___**	**Activity ___**	**Activity ___**	**Activity ___**	**Activity ___**
INTRODUCTION	3. Start of introduction (min:sec):					
	4. End of Introduction (min:sec):					
	5. Explicitly encourages students to focus on logic:	Y N	Y N	Y N	Y N	Y N
	6. Explicitly encourages students to use prior knowledge:	Y N	Y N	Y N	Y N	Y N
	7. Explicitly reminds students that errors are natural and useful/educational	Y N	Y N	Y N	Y N	Y N
	8. Bloom Level of Activity: Higher order, (H) Lower order (L), Course Logistics (C), Opinion Poll (O)	H L C O	H L C O	H L C O	H L C O	H L C O
	9. Form of Activity: Clicker Q (C), Worksheet (W), etc.					
STUDENT ENGAGEMENT (SE): During ANY Iteration	10. Instances of explicit positive feedback or encouragement: Directed towards entire class (C), Directed towards individual students (S)	C: S:	C: S:	C: S:	C: S:	C: S:
	11. Instances of praise or encouragement referencing effort or improvement:					
	12. Instances of explicit negative feedback: Directed towards entire class (C), Directed towards individuals (S)	C: S:	C: S:	C: S:	C: S:	C: S:
	13. Explicitly encourages students to focus on logic:	Y N	Y N	Y N	Y N	Y N
	14. Explicitly encourages students to use prior knowledge:	Y N	Y N	Y N	Y N	Y N
	15. Explicitly reminds students that errors are natural and useful/educational	Y N	Y N	Y N	Y N	Y N
	16. Total number of students heard:	V: R:	V: R:	V: R:	V: R:	V: R:

		C:	C:	C:	C:	C:
	17. Number students who explain logic behind their response.					

Descriptive Account of Session:

Time Running notes [Comments]

Initial interpretations and follow-up questions:

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