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Mathematics Identity Construction in Successful African Americans: Reflections on Mathematics Experiences During Adolescence

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

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ABSTRACT

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Teri Nicole Johnson

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This project used narrative inquiry to examine adolescent experiences that contributed to the development of positive mathematics identities in successful African Americans. Ten African Americans, who had worked in a STEM-related occupation for at least two years, were asked to reflect on in- and out-of-school experiences with mathematics during their middle and high school years. Data collection included individual interviews and one focus group discussion. A combination of internal and external factors emerged as contributors to participants' adolescent mathematics identities. Internal factors included early career interest, finding enjoyment in the challenges associated with learning mathematics, or facing setbacks they were determined to overcome. External influences included parents/family members, teachers/school staff, and peers who were influential agents in participants' mathematics socialization. Participants' stories revealed that mathematics identities were developed in several communities of practice—the

mathematics classroom, after-school (or school-affiliated) programs, summer programs, and during unstructured free time. The findings offer three possible applications to practice: 1) Continue developing school-based and out-of-school programs aimed at exposing African American adolescents to STEM and allowing them to apply the knowledge gained in the classrooms in the real world; 2) Increase efforts to educate African American parents about the variety of occupations related to STEM and the foundational knowledge needed to gain access to these occupations; and 3) Continue efforts to recruit African American secondary teachers for STEM-related courses.

Chapter 1 INTRODUCTION

As an African American graduate student at the end of a doctoral program, I can reflect on many opportunities that were available to me, in part, because I finished high school with a strong mathematics foundation and positive self-perceptions as a learner and doer of mathematics. During my undergraduate studies, I successfully completed several advanced science and mathematics courses. When I decided to become a teacher, that coursework satisfied the requirements needed to earn certifications in secondary mathematics and science. A few years into my teaching career, I decided to return to graduate school for my Master's degree, and a decade later, a doctoral degree. Once again, my mathematics background served me well. I did not have trouble earning the scores required on the quantitative reasoning portion of the GRE and I enjoyed my graduate-level statistics coursework while many of my peers dreaded the courses.

I taught middle school mathematics and science for 12 years before returning to graduate school to pursue educational research. My decision to teach these two subjects was partially driven by the lack of teachers who looked like me in my middle and high school classes. I experienced several defining moments with Caucasian teachers who, despite my status as honors student, held low expectations for my performance and underestimated my potential. I was fortunate to have support systems outside of school that helped bolster my mathematics identity development despite negative experiences at school. I know what worked for me; for this project I wanted explore the experiences of other African Americans for whom mathematics served as a gateway to success.

Overview

This study used narrative inquiry to examine the mathematics identities of successful African Americans and the middle and high school experiences that supported positive identification with mathematics. Success was defined as having worked in a science, technology, engineering, or mathematics (STEM)-related occupation for a minimum of two years. Participants were recruited from a diversity of STEM-related careers. Ten African Americans, who identified as male or female, were interviewed individually. Four of them also participated in a focus group discussion. They were asked to reflect on in- and out-of-school experiences and interactions during adolescence that contributed to their self-perceptions and engagement as learners and doers of mathematics. Working from an assumption that discussion of different mathematical concepts could also provide insight into their mathematics identities, participants were asked to reflect on the mathematical knowledge that provided the foundation they needed to pursue their desired careers. Some might question the decision to consider the relationship between an individual and mathematics in what seems to be a tangential way. I argue that how an individual directly relates to mathematics knowledge and skills is among the factors in success; however, it is also true that the relationships individuals have with mathematics are mediated by several social factors that cannot be entirely disentangled.

Mathematics is considered a gatekeeper to upper level coursework in high school and college and, later, to many career opportunities (Battey, 2013; Moses & Cobb, 2001). Insight into the experiences of African Americans who were able to "get past the gate" may inform the development of supports and interventions for the disproportionate numbers of African American adolescents who struggle with mathematics and subsequently lose access to opportunities in STEM-related occupations. The qualitative approach in this project was not intended to ascribe a

causal link between experiences and mathematics identity; however, this research does argue that collective experiences contribute to individuals' self-perceptions as learners and doers of mathematics. Therefore, the use of phrases such as "contribute to" or "influence the development of" was unavoidable when discussing this phenomenon.

This chapter begins with a discussion of the background and context framing the purpose of the study. The problem statement, research questions, a discussion of the researcher's positioning and assumptions, and rationale for the study follow the background and context. The chapter concludes with a description of key terminology.

Background and Context

A 2017 survey conducted by Change the Equation revealed that 93% of Americans expressed a belief that the development of good math skills is important to being successful in life. However, the survey also showed that 63% of Americans reported difficulty applying math skills in their everyday lives (e.g., calculating tax or discount, estimating distance or weight, managing a budget). Additionally, one third of the individuals surveyed indicated they are not good at math and approximately 20% reported feeling frustrated or anxious when faced with using math (Change the Equation, 2017).

Though many people agree on the importance of mathematical knowledge, an aversion to or avoidance of mathematics often does not elicit the concerned reactions that would arise if individuals revealed similar feelings about other key areas (e.g., reading). The expression of negative feelings towards mathematics can elicit empathy or commiseration. It is seemingly the only subject where students' poor performance can lead to statements such as, "Lots of people struggle. Just do your best and try not to fail," (Boaler, 2015; Moses & Cobb, 2001). Offering struggling learners this type of consolation is misguided, however, because obtaining an education

that includes successful completion of a rigorous mathematics sequence opens gateways to careers that increase an individual's chances for economic security and enfranchisement (Battey, 2013; Moses & Cobb, 2001; Schoenfeld, 2002). This is as true for young adults who elect to enter the workforce upon finishing high school as it is for those who choose to pursue postsecondary education (ACT, 2006; Kiersz, 2015; Moses & Cobb, 2001; Schoenfeld, 2002).

Mathematics literacy can serve as either a gateway or gatekeeper to academic and economic advancement (Battey, 2013; Moses & Cobb, 2001; Schoenfeld, 2002). Many of the most in-demand industries—regardless of the need for postsecondary education—require employees who are proficient in mathematics (ACT, 2006; Kiersz, 2015; Moses & Cobb, 2001). A large percentage of current high-demand careers and those projected to grow the fastest over the next decade are STEM-related occupations (U.S. Bureau of Labor Statistics (BLS), 2017).

Findings by Randstad North American (2017) reveal a need to rebrand STEM and expand on the narrow band of professions (e.g., scientists, IT workers, engineers, and mathematicians) typically considered to be STEM occupations. The researchers recommend considering the STEM skills needed in jobs generally not associated with STEM. This suggestion is based on a finding that more than three fourths of the fastest-growing jobs in the United States require mastery of mathematics and scientific knowledge and skills (Randstad North America, 2017). Since STEM careers are often associated with formal postsecondary schooling, I elected to use the phrase *STEM-related occupation* for this project which was intended to be more inclusive of what is considered a STEM career. STEM-related occupations go beyond careers such as finance, technology, engineering, and healthcare to include other professions for which mathematical knowledge is a prerequisite for entrance. For example, occupations that do not require college such as electricians, carpenters, building inspectors, and plumbers are examples of STEM-related careers because they incorporate mathematics (e.g., algebra and/or geometry) into their training or

apprenticeship programs (BLS, 2017). My hope is that offering more inclusive definitions of "STEM career" and "success" will widen the range of opportunities for students to consider after exiting high school and magnify the importance of providing a solid mathematics foundation to *all* K-12 students.

Minority Status and Mathematics: Gateway or Gatekeeper?

Disproportionate numbers of minority students underperform and eventually disengage from mathematics (Delpit, 2012; Ogbu, 2002; Schoenfeld, 2002). There have been many waves of school and curricular reform efforts aimed at increasing minority students' outcomes in mathematics that have proved insufficient at closing the performance gap between African American, Latino, and Native American students and their Caucasian and Asian peers. African American, Latino, and Native American students are overrepresented in the lowest performance levels on multiple measures of mathematics proficiency in elementary (e.g., 4th grade NAEP), middle (e.g., 8th grade NAEP), and high school (12th grade NAEP, SAT, and ACT) (ACT Inc, 2017; Nation's Report Card, 2017; U. S. Department of Education, 2016). The Business-Higher Education Forum (2011) reports that students from these minority groups are more likely than Caucasian or Asian Americans to express interest in STEM-related careers but lack the mathematics proficiency necessary to pursue those interests. This phenomenon likely contributes to the underrepresentation of members of these racial and ethnic groups in STEM careers and other high demand occupations (BHEF, 2011) and closes multiple pathways to economic enfranchisement (Battey, 2013; Moses & Cobb, 2001; Schoenfeld, 2002).

One promising approach to confronting achievement disparities is the acknowledgement and close examination of the powerful sociocultural factors that influence mathematics learning (Gutierrez, 2013; Lerman, 2000; Martin, 2000; Ogbu, 2002). Experiences within and outside of

formal school environments communicate implicit and explicit messages to students about who they are, can, or should be in relation to mathematics (Delpit, 2012; Martin, 2000, 2007; Nasir & Hand, 2008). Martin (2000, 2006, 2007) refers to these experiences and messages as mathematics socialization. The encouraging or discouraging nature of individuals' mathematics socialization impacts the stories they tell themselves about their ability to learn mathematics (Delpit, 2012). These stories and beliefs can subsequently impact their motivation and persistence to gain mathematical knowledge (Martin, 2000, 2006, 2007).

The development of a negative mathematics identity can lead to underperformance, disengagement, and non-participation in mathematics (Grootenboer & Zevenbergen, 2008; Martin, 2000, 2006). Identification as a mathematics learner differs from learners' identities in relation to other subjects because mathematics achievement is frequently considered a proxy for intelligence in our society (Gutierrez, 2015). Not seeing oneself as a "math person" can have lasting consequences for students' course-taking patterns, academic outcomes, and selection of careers (Gutierrez, 2015; Moses & Cobb, 2001; Schoenfeld, 2002).

A synthesis of research from Oremod & Duckworth revealed that between the ages of eight and fourteen is a critical time for developing students' interest in math and science-related careers (Sneider, 2011). These findings are supported by additional research that shows middle school mathematics and science interest and achievement to be positively associated with STEM interest in high school and college (Dabney et al., 2012). Underperformance in the lower grades often leads to dropping out of mathematics before reaching upper level coursework in high school (Martin, 2000, 2006; Schoenfeld, 2002). Given that many of the jobs of the future are in STEM-related professions, it is critical to prevent students from disengaging from mathematics early in their education.

Problem Statement

African American students are more likely to perform at the lowest levels of proficiency on assessments of mathematical knowledge (ACT.org, 2017; Nation's Report Card, 2017; U.S. Department of Education, 2016). Additionally, African Americans' are underrepresented in upper-level high school mathematics and science courses, STEM majors in college, and later, in many of the highest demand and fastest growing professions (BHEF, 2011; U.S. Department of Education, 2017). A pernicious narrative has emerged from statistics such as those referenced above suggesting that African Americans are less capable than members of other racial groups of learning and doing mathematics (Berry, 2005, 2008; Martin, 2006; Nasir & Shah, 2011). However, complex factors such as inequitable access and opportunity to learn contribute to outcomes such as unduly low achievement on measures of mathematical knowledge and underrepresentation in STEM-related endeavors.

Despite the concerning statistics related to African American learners' proficiency, there are many African American students who are successful learners and doers of mathematics (Berry, 2005, 2008; Berry, Mcclain, & Thunder, 2011; Borum & Walker, 2011; Martin, 2000; Stinson, 2008). This project focused on how experiences in adolescence can support positive identification with mathematics. Being able to see oneself as a person capable of learning and doing mathematics likely impacts African American learners' engagement, motivation, and persistence to gain mathematical knowledge. As such, it is important to understand the interactions and practices that facilitate the development of positive mathematics identities in African American students. There is a large volume of mathematics identity research; however, more research is needed that considers the perspectives of African Americans who demonstrate long-term persistence with mathematics and leverage their mathematical knowledge to pursue a variety of opportunities after

completing their K-12 education. These individuals offer counternarratives that challenge misconceptions about African American students' ability to fully engage with mathematics.

Statement of Purpose and Research Questions

This study examined the narratives successful African American adults told about their self-perceptions and engagement with mathematics. For the purposes of this inquiry, *success* was defined as working in a STEM-related profession for a minimum of two years. Participants reflected on their adolescent years and the experiences that facilitated or impeded positive identification with mathematics. They were also asked to consider how the intersection of their mathematics and other identities (e.g., gender, racial) impacted their engagement with mathematics. Lastly, to give further insight into their identification with mathematics, participants were asked to share their perspectives on the mathematical skills and concepts that provided the foundational knowledge necessary to pursue their goals. The following research questions were studied through this inquiry:

1. *What stories do successful African Americans tell related to their mathematics identities and engagement with mathematics?*
2. *What interactions, experiences, or practices during adolescence contributed to the development of their mathematics identities?*
3. *How did the construction of participants' mathematics identities align with or contradict their other identities? How did they negotiate any contradictions?*
4. *What mathematics concepts and skills do participants highlight as useful for being prepared to pursue the training necessary for their careers?*

Research Approach

Narrative inquiry was selected to explore the factors contributing to the development of successful African Americans' mathematics identities during their adolescent years. "Narrative stories tell of individual experiences and they may shed light on the identities of individuals and how they see themselves" (Creswell & Poth, 2017, p. 69). A combination of purposeful and snowball sampling was used to recruit ten African Americans working in STEM-related occupations. Examples of these occupations included, but were not limited to, accounting/finance, education, engineering, healthcare, informational technology (IT), and trades (e.g., electrical, plumbing, carpentry). Data collection included completion of a Participant Information and Math History Form, individual interviews with each participant, and one focus group discussion consisting of four participants. Data analysis included individual and focus group interview transcription followed by iterative stages of thematic coding using ATLAS.ti. Data sources were used to generate narrative profiles for each participant. These profiles were shared with each participant along with their individual interview and (if applicable) the focus group transcript to ensure their experiences and perspectives were accurately represented.

Positioning the Researcher

As a teacher, I encountered a disconcerting percentage of African American students who disengaged and underperformed in mathematics. Some exerted minimal effort because they felt they were incapable of learning mathematics. Others seemed to downplay their interest or achievement to avoid being stigmatized or ostracized by their peers. As an individual who was often one of two or three African American students in Honors classes during middle and high school, I identified with the tension some of my students experienced between being a high achiever and fitting in with African American peer groups in the school. The way I was treated by

other African American students suggested I was supposed to choose one or the other. It was not "cool" to be an African American honors student. Reflecting on my adolescent experiences of reconciling two, at times contradictory, worlds and observing my students facing similar challenges left an impression on me that eventually drove me to this line of research.

During my years in the classroom, I also worked with many parents who felt unable to support their children because they too struggled with math. I was frequently told, "I'm not good at math either. It runs in the family" as though math proficiency is an inherited trait. As I experimented with different strategies to engage students with mathematics I was able to make some gains in their motivation and performance; however, I learned that engaging with and learning mathematics requires more than just "good teaching." If students do not believe in their ability to be successful, it is difficult to maintain the necessary level of commitment or demonstrate sustained growth. My experiences (and frustration) in trying to move so many of my African American students to reach their potential in mathematics sparked my interest in the forces that pose barriers to students' beliefs about whether they can be a 'math person.'

Exposure to the mathematics education literature after beginning my graduate program gave a name to my interest, *mathematics identity*, and led me to the work of other individuals examining mathematics engagement among African American learners such as Robert Q. Berry, III, Danny B. Martin, Ebony McGee, David Stinson, and Na'ilah Suad Nasir. In studying the development of African American learners' mathematics identities, I hope to learn how socializing agents (e.g., parents, teachers, peers, mentors) (Young, Young, & Capraro, 2017) impede or facilitate the development of those identities, particularly during adolescence. My goal is to add to a body of research that sheds light on supports and interventions that can bolster African American students' identities and prevent disengagement from mathematics in middle and high school.

Diversifying the STEM workforce and increasing the number of minority secondary mathematics and science teachers are among my motivations for increasing minority students' achievement in mathematics. However, my commitment to increasing the representation of minorities in STEM occupations should not be taken to mean that I believe all minority adolescents should pursue a STEM-related occupation. My aim is for all students to exit high school with a foundation of mathematical knowledge that makes pursuing a STEM-related major or occupation accessible for any student who aspires to follow that path. I do not want mathematics anxiety or an aversion to mathematics to limit any student's perception of the options available to them after high school.

Assumptions

Four assumptions underlie this research; the first being that working in a STEM-related occupation is positively associated with a positive mathematics identity. Support for this assumption can be found in research that demonstrates a strong positive correlation between math and science interest during K-12 schooling and pursuit of a STEM career (Dabney et al., 2012; Maltese, Melki, & Wiebke, 2014; Tai, Liu, Maltese, & Fan, 2006). A second assumption is that learners' self-perceptions related to mathematics (i.e., their mathematics identity) impact their participation in the practices that support the learning of mathematics, their willingness to risk making mistakes, and their motivation to persist when learning becomes difficult. After interviewing African American adults who reported disengaging from mathematics during middle or high school, Martin (2006, 2007) quoted several participants who attributed their disengagement to not viewing themselves as "math people." A third assumption of this project is that African Americans are not underrepresented in STEM-related occupations due to lack of interest or ability but due to multiple factors that limit access to pathways to these careers. One of these factors is

insufficient mathematics literacy to satisfy the requirements for entrance into these fields. Research by the Business-Higher Education Forum (BHEF, 2011) offers support for this assumption as African Americans students were found to be more likely than Caucasian or Asian American students to express interest in STEM-related careers but lack the mathematics proficiency necessary to pursue those interests. The fourth and final assumption is that the mathematical knowledge learned through the end of middle school (Pre-algebra or Algebra 1) is foundational for secondary mathematics and science coursework. This foundational knowledge, or lack thereof, impacts course-taking patterns and readiness for STEM-related courses in high school and college. Algebra 1 is generally identified as the gateway course to a rigorous sequence of mathematics coursework (Domina, 2014; Moses & Cobb, 2001).

Study Rationale and Significance

Berry (2005) emphasizes the importance of learning about the experiences of successful learners when considering student achievement-

> In order for more African American males to achieve success academically, it is critical to focus on the success stories of those African American men and boys who are successful to identify the strengths, skills and other significant factors it takes to foster success. In addition, it is important to identify the limitations that these males have experienced. African American males who experience success academically can provide the basis for examining the challenges confronting all African American males (p.47).

Berry's argument is not limited to African American males. Studies of successful individuals from any historically underserved or marginalized group can illuminate potential challenges facing many members of the group and provide insight into individuals' agency and resilience in the face of those challenges. Many studies of successful African American mathematics learners focus on middle or high school students (e.g., Berry, 2005, 2008; Berry et al., 2011; Martin, 2000; McGee & Pearman, 2014, 2015). While these studies offer valuable information about mathematics identity development during adolescence, the trajectory of those

participants and their persistence with mathematics into adulthood is unknown. Borum and Walker (2011) offer an exception to this claim. Their research participants are African American women holding doctoral degrees and working careers in mathematics and the researchers delve deeply into these women's experiences during their formative and pre-college years.

There is a body of research focused on mathematics identity in successful African American college students enrolled in STEM majors (e.g., Ellington & Frederick, 2010; McGee, 2015; McGee & Martin, 2011; Moody 2003, 2004). Many of these studies limit the focus to students' interactions and experiences while in the university setting; however, there are inquiries that solicit participants' reflections on pre-college experiences such as Stinson (2008) who documents the mathematics stories of four African American male college students with a focus on their high school years. Similar to Borum and Walker (2011), Ellington and Frederick (2010) probe African American undergraduate mathematics majors' early and adolescent experiences and their contributions to success and persistence in the discipline. The aforementioned studies share a limitation of restricting participation to African American learners pursuing postsecondary education. Therefore, they do not include the voices of successful African Americans who elect to enter the workforce after high school.

Martin (2000, 2006, 2007) includes individuals in later stages of adulthood—who did not attend college—in his studies of mathematics socialization and the construction of mathematics identity in African American learners. He argues that adults can offer detailed perspectives on issues of race and learning mathematics in ways that children and adolescents may not be able or willing to articulate. The narratives Martin chose to highlight describe the experiences of individuals who developed negative mathematics identities during their K-12 years of schooling but re-invested in mathematics later in life. My project could be viewed as a complement to Martin (2006, 2007) as it offers the perspectives of African American adults who developed positive

mathematics identities during K-12 schooling and continued engaging with mathematics after high school. Participants were given an opportunity to reflect on their adolescent years with a different level of understanding of their experiences—and possibly new language to describe them—that may not have been available to them during that stage of their development.

The science education literature includes several studies that probe the impact of pre-college experiences on STEM professionals' science identity development and later engagement with science (e.g., Carlone & Johnson, 2007; Maltese & Tai, 2010; Nazier, 1993). Carlone and Johnson (2007), a seminal study in the science identity research, examined the pre-college experiences contributing to the science identity development of successful women of color. This study will make a similar contribution to the mathematics education literature by asking African Americans who ultimately "made it" to reflect on the secondary school experiences that contributed to the development of their mathematics identities. Learning more about the experiences of successful African Americans and how various factors facilitated or impeded their engagement with mathematics has implications for the development of supports and interventions for today's African American youth (Martin, 2007). I hope that the themes emerging from this study can be applied to future studies on the development of African American adolescents' mathematics identities.

This study is in no way intended to essentialize African American mathematics learners. Individual experiences vary within and across different membership groups. However, individual variability within the African American community does not negate the significance of commonalities that occur as a result of the salience of race and racial marginalization in our societal structures (Martin, 2007; Simpson and Parsons, 2008). Systematic examinations of those common experiences can offer insight that informs efforts to improve the educative experiences of African American learners.

Research by Steinberg, Dornbusch, and Brown (1992) suggests that influences on academic engagement and achievement vary by race/ethnicity. However, the focus on African Americans in this study is not meant to suggest that the influences on African American learners' mathematics identity development are unique to African Americans. In the future, I hope to replicate this study with a larger, more diverse sample of participants to examine how the collective experiences contributing to adolescents' mathematics identity development compare within and across racial and ethnic subgroups. While this line of research is not intended to be generalizable in the strict sense of the term, findings may help inform studies of other groups of learners that have historically underperformed or been marginalized in mathematics (e.g., Latino/as, Native Americans, Asian subgroups, English language learners, and students with disabilities).

Operationalizing Mathematics Literacy

Robert Moses argued that mathematics and science literacy are the civil right of the 21st century. He stressed that if people of color were to "function in society, have economic viability, be in a position to meaningfully participate, and have some say-so in the decision making that affects their lives," (Moses & Cobb, 2001, p. 14) they could not afford to be illiterate in mathematics. At the heart of this research is a commitment to make mathematics knowledge accessible to minority students and their families so they can fully access their rights of citizenship. Labaree (1997) outlined what he saw as three conflicting goals for the American education system-democratic equality (i.e., preparing informed citizens), social efficiency (i.e., preparing workers for the labor force), and social mobility (i.e., preparing individuals for social positions). Do these goals have to be mutually exclusive? Can mathematics literacy simultaneously open a wider array of opportunities for individuals (social mobility), produce a populace capable of understanding, interpreting, and critiquing information to make informed decisions for their communities and the

larger society (democratic equality), and develop a workforce replete with individuals who hold the foundational knowledge and skills needed for the jobs of the future (social efficiency)? I believe a mathematically literate populace can support each of those goals; however, this study—with its emphasis on STEM-related occupations—is admittedly more focused on social mobility and social efficiency.

Throughout this study the terms mathematics literacy, mathematics proficiency, and mathematical knowledge are used interchangeably. The National Research Council (2002) identified five essential strands for mathematical proficiency: 1) comprehension of mathematical concepts, 2) computational fluency, 3) application of mathematical concepts to solving problems, 4) logical reasoning, and 5) engagement (i.e., viewing mathematical knowledge as sensible, useful, and doable). Cobb (2004) indicates that there are multiple types of mathematics literacy. For example, mathematicians, school mathematics teachers, and laypersons will engage with mathematics in different ways. Boaler and Greeno (2000) describe mathematics knowing and understanding as "engag[ing] in sense-making and problem solving using mathematical representations, concepts, and methods as resources" (p. 172). Critical mathematics educators Gutstein and Peterson (2013) emphasize the "power of mathematics as an essential analytical tool to understand and potentially change the world, rather than merely regarding math as a collection of disconnected rules to be rotely memorized and regurgitated" (p. 2).

Each of these perspectives contributes to the view of mathematics literacy/proficiency taken for this project, which includes flexible computation and estimation skills, a conceptual understanding of "big idea" mathematical concepts through high school geometry—proportional reasoning, probability and statistics (i.e., data representation and interpretation), linear functions, systems of equations, and attributes and relationships of geometric objects—and the ability to apply these concepts to real-world problems and situations. The goal of improving mathematics

literacy to increase the representation of minorities in the STEM-related occupations should not be interpreted as advocating for requiring all high school graduates to complete upper-level mathematics coursework through calculus to be considered mathematically literate or proficient. However, I do argue that all students should exit high school with a foundation of mathematical knowledge and skills that make it possible to pursue any desired mathematics training or coursework beyond high school geometry. Additionally, all citizens need a foundation of mathematical knowledge that allows them to interact and think more critically about the world (Gutstein & Peterson, 2013; Labaree, 1997).

Definitions of Key Terminology

Socializing agents – individuals or structures (e.g., family members, teachers, peers, curriculum materials, popular media) that communicate explicit or implicit messages to young people and contribute to their self-perceptions or perceptions of the world (Young et al., 2017)

STEM-related occupation – careers that require application of science, technology, engineering, or mathematical knowledge in daily operations or that require STEM-related coursework, training, or testing to obtain the certifications required for employment; these careers may or may not require completion of a postsecondary degree

Success – working a STEM-related occupation for a minimum of 2 years

Chapter 2 LITERATURE REVIEW

Overview

This review of the literature begins with an overview of four frameworks for considering identity as a theoretical lens in educational research. Following the presentation of the individual frameworks, an explanation is provided for how they each contributed to the theoretical framework for this study. The frameworks are followed by a synthesis of identity research specifically related to mathematics education. The focus then narrows to an emphasis on mathematics identity development among African American learners before concluding with an explanation of how mathematics identity development was conceptualized for this study.

Literature searches were conducted using the databases Academic Research Complete, ERIC, Google Scholar, and PsychINFO with search terms such as "*identity and education", "mathematics identity", "mathematics education and identity", "African American and mathematics",* and *"successful African Americans".* Identity research in education is often divided into one of two foci: professional teacher identity or learner identity. Due to the large volume of research available, the identity literature reviewed for this project, related specifically to mathematics identity, is limited to identity development in the role of mathematics learner. The sources for this review were found in scholarly, peer-reviewed journals (theoretical pieces, literature reviews, and empirical studies), dissertations, books, or academic media sources. Book reviews and popular media sources were excluded.

Identity as a Theoretical Lens

Identity in Practice

Wenger (1998) characterized identity as how an individual defines who they are based on their lived experiences and participation in communities of practice. Communities of practice are social communities in which individuals share a common set of beliefs and/or practices. Individuals construct their identities in relation to their participation (or non-participation) in these communities. These constructions are influenced by the way individuals experience themselves through participation in a community of practice as well as by the way their participation is reified (i.e., legitimized or reinforced) by other members of the community. At any given time, individuals are members of several communities of practice and many of these memberships change over the course of a lifetime. As such, the work of identification and negotiating the self is ongoing. "Identity is not some primordial core of personality that already exists" (Wenger, 1998, p. 154). Individuals engage in different practices within their different communities, thus gaining different perspectives and constructing different aspects of the self (Wenger, 1998). The multiple aspects of the self may conflict or make competing demands on an individual; therefore, identity work requires reconciling "different meanings, forms of participation, and forms of accountability into…a way of being in the world" (Wenger, 1998, pp.159-160).

Identity construction emanates from both the practices in which individuals engage and those practices in which they do not engage. "In practice we know *who we are* by what is familiar, understandable, usable, negotiable; we know *who we are not* by what is foreign, opaque, unwieldy, unproductive" (Wenger, 1998, p. 153, emphasis added). Within a spectrum ranging from full participation to non-participation in communities of practice, Wenger (1998) identified two forms of limited participation. Peripheral participation is a degree of non-participation in preparation for full participation at a future time. Newcomers to a community of practice often engage in

peripheral participation (e.g., shadowing or observing) until they are ready to engage in full participation with established community members. Marginal participation, on the other hand, is a form of non-participation characterized by the intent to limit or prevent full participation of some members in a community of practice. The communities of practice in which individuals do not engage or experience marginalized participation can become very significant in how they define themselves (Wenger, 1998).

Identity Within Figured Worlds

Holland, Lachicotte, Skinner, and Cain (1998) described identity as self-understandings that form and re-form through activity and social interaction in figured worlds. Figured worlds are social and cultural realms to which individuals are drawn, recruited, or required to enter. These worlds are constructed and shaped by the collective imaginings and work (i.e., activities, discourses, performances) of the characters and agents within them. The self-understandings gained from these worlds facilitate individuals' behavior. "People tell others who they are, but even more important, they tell themselves and then try to act as though they are who they say they are" (Holland et al., 1998, p.3). Holland and colleagues (1998) posit that individuals are composites of many, often contradictory self-understandings and identities developed from participation in different figured worlds.

Encounters within figured worlds relegate individuals to certain roles or positions within the social organization. Through day-to-day interactions, individuals "come to identify themselves as actors of more or less influence, more or less privilege, and more or less power in these worlds" (Holland et al., 1998, p. 60). The roles or positions learned in figured worlds are not deterministic, however. Individuals have agency over their own behavior and, by extension, have some degree of agency over their status within figured worlds.

Identity as Recognition as a Certain "Kind of Person"

Gee (2000) defines identity as "being recognized as a certain 'kind of person' in a given context" (p. 99), while allowing for some agency in how a person views him or herself. Like Wenger (1998) and Holland et al. (1998), Gee posits that individuals have multiple identities associated with their performances in different contexts that are susceptible to change as interactions and contexts change. Gee (2000) outlines four sources contributing to how individuals see themselves or are recognized by others.

N-identities. Nature identities derive from recognition as a certain type of person based on innate (i.e., biological) characteristics that are out of the control of the individual and society (e.g., Gee identifies himself as an identical twin). Nature identities gain significance in relation to the way in which certain characteristics become salient and impact how individuals are recognized within the three other sources of identity— institutions, discourse, and affinity groups.

I-identities. Institutional identities are authorized, bestowed or imposed on individuals within society's institutional structures (e.g., being hired into a faculty position authorizes the identity of college professor; being arrested bestows the identity of prisoner; living in poverty imposes the identity of being 'at risk' for educational failure). The amount of agency (i.e., control) one has over I-identities varies. Regardless of the manner in which these identities are received, they can lead to individuals being socialized to perform in a manner consistent with expectations for the assigned identity. Additionally, I-identities can result in performances or behaviors being perceived by other individuals in a specific way (i.e., through a narrow lens) as opposed to other possible interpretations.

D-identities. Discursive identities are achieved or ascribed based on the narratives or dialogue of other people in recognition of certain traits in an individual (e.g., an outgoing

individual may be characterized by others as charismatic, thus eliciting more outgoing/charismatic behavior) (Gee, 2000). Similar to I-identities, there is a continuum of how much agency individuals have over the identities assigned to them based on the recognition and dialogue of others. However, individuals may have more control over negotiating D-identities (i.e., being seen a certain way by others) through the nature of their social interactions with other individuals than when dealing with institutions.

A-identities. Affinity identities result from a shared allegiance or participation in the practices of a specific membership group (e.g., Star Trek fans identifying as "Trekkies") (Gee, 2000). Affinity groups can develop from individuals actively seeking out and joining like-minded others. They also can be manufactured by institutions through encouraged or mandated shared practices among groups of individuals for the purpose of benefitting the institution.

The four sources of identity reflect how an individual's identities function within a specific context or across different contexts (Gee, 2000). Gee emphasizes that identities are not static and that individuals can accept or resist identities ascribed to them by institutions, other individuals, or groups of individuals. He also points out that while the four identity sources are not mutually exclusive, considering them separately helps draw attention to distinct factors contributing to identity formation that are interrelated in "complex and important ways" (Gee, 2000, p. 101).

Identity as Reifying, Endorsable, and Significant Stories

Sfard and Prusak (2005) suggest that identity could be the "missing link in…the complex dialectic between learning and its sociocultural context" (p. 15). They critique prior attempts at describing identity as "promising beginnings" that have not been sufficiently operationalized, pointing out that Wenger's (1998) discussions of "identity construction" and "identity in practice" are presented without conceptual preparations that lay the foundation for understanding what

identity is. They further argue that Holland et al.'s (1998) and Gee's (2000) conceptions of identity fail to make explicit *how* (emphasis added) one can determine "who" or "what kind of individual" one is (Sfard & Prusak, 2005, p. 16). The authors go on to caution that Gee's (2000) description of being seen as a "certain type of person" makes identity seem as though it is something given by others, independent of an individual's actions. They argue that his interpretation is an essentialist view vulnerable to self-fulfilling prophecies and negative connotations.

Sfard and Prusak (2005) ultimately operationalize identity as collections of *reifying, endorsable, and significant* stories or narratives about individuals. They argue that the emphasis of identity as collections of stories highlights the fact that identities are human-made rather than God-given. Authors and recipients collectively shape identities, leaving them amenable to change based on their (recipients' or authors') needs and perceptions (Sfard & Prusak, 2005). Reifying (i.e., reinforcing) stories include descriptors such as "*be, have, or can* rather than *do*" accompanied by adverbs such as "*always, never, usually,* and so forth, that stress repetitiveness of actions" (Sfard & Prusak, 2005, p. 16, emphasis in original). Endorsable stories are those an individual would agree accurately reflect their view of the "state of affairs in the world" (Sfard & Prusak, 2005, p. 16). Stories and narratives gain significance if a change in them would likely impact the storyteller's perceptions of the identified individual. The narratives given the most significance are generally "those that imply membership in, or exclusions from, various communities" (Sfard & Prusak, 2005, p. 17). This declaration echoes Wenger's (1998) indication that identities are constructed from both the practices in which individuals engage and those in which they do not engage.

Like Wenger (1998), Holland et al. (1998), and Gee (2000) before them, Sfard and Prusak (2005) posit that individuals have multiple, concurrent identities ascribed from various storytellers. These identities can differ at times to the point of being contradictory. They refer to storytellers

who have the most impact on individuals' identities as *significant narrators*. Examples of significant narrators are the self, authority figures, peer groups, and institutions. The authors distinguish between three sources of storytelling and corresponding forms of identity. A *first-person* identity is an identifying story narrated about oneself while an identifying story told to an identified individual is called a *second-person* identity. A story told about an identified individual by a third party to another third party is considered a *third-person* identity. Sfard and Prusak (2005) posit that *first-person* identities are part of ongoing conversations individuals have with themselves and, as such, are most likely to have an immediate impact on one's actions. However, they emphasize that *second-* and *third-person* identities often become incorporated into individual's stories about themselves, thus contributing to their behaviors.

In addition to differentiating between the sources of identity narratives, the authors present two subsets of identity, actual and designated. Actual identities are stories formulated as factual assertions stated in the present tense. Statements beginning with *I am… or I have…* narrate actual identities. Designated identities are stories expected to be, or with the potential to become, part of an individual's actual identity at some point in the future. Narratives of designated identities include words such as "*should, ought, have to, must, want, can,* [and] *cannot*" (Sfard & Prusak, 2005, p. 18). Designated identities influence individuals' actions as they seek to close perceived gaps between who they are (actual identity) and who they think (or are told) they should become (designated identity). Designated identities are troublesome in that individuals' self-designated identities are often constructed from stories received from people in positions of authority and power. These significant narrators can lead individuals to adopt certain narratives without deliberate, rational choice (Sfard & Prusak, 2005). The resultant significant and endorsable stories can prevent individuals from seeing certain narratives as merely "stories" that can be revised and retold.

Identity Frameworks' Application to this Research

There are several shared aspects among the aforementioned identity frameworks. Wenger (1998), Holland et al. (1998), Gee (2000), and Sfard and Prusak (2005) all emphasize that identity is a multidimensional construct. There is no "core identity." Rather, individuals construct different identities across different contexts. At times these identities can come into conflict or contradict one another. Additionally, each framework posits that identities are not static. Identity construction (and re-construction) is an ongoing process as individuals negotiate their experiences and interactions. The frameworks also highlight the role of social interactions within identity development. Identities are not constructed in a vacuum. Individuals develop perceptions of the self and adopt corresponding behaviors in response to social interactions and recognition by other individuals. Finally, each framework alludes, to some degree, to the role of social positions (i.e., power, privilege, or lack thereof) in bestowing or imposing identities onto individuals.

Individually, the frameworks illuminate certain important aspects of identity construction while providing less insights into other aspects. An integration of the frameworks can offer a more comprehensive picture of identity development. For example, Gee (2000) highlights specific sources contributing to identity development in a way not addressed by the other models. His conception of identification, however, emphasizes sources that are external to the individual and dependent on recognition by others, thus minimizing the role of individual agency. Sfard and Prusak's (2005) concepts of *first-*, *second-*, and *third-person* identities add an internal (within the individual) component to identity development without diminishing the role of recognition by others. Their conception of identity as a series of narratives developed through collective storytelling is limited, however, because it does not emphasize the performance aspect of identity. Wenger's (1998) notion of *identity in practice* supplements Sfard and Prusak's (2005) conceptualization by emphasizing that identity construction is not limited to who an individual (or

others) thinks they are, but is also based on an individual's actions. Holland et al. (1998) also discuss the relationship between an individual's view of their self and their behavior, elaborating on the role of agency in identity construction. An additional strength of Wenger's (1998) framework is that the notion of communities of practice offers a more concrete representation of the experiences and interactions (e.g., full participation, non-participation, peripheral, and marginal participation) that take place in socially and culturally constructed realms than Holland et al.'s (1998) similar, but more abstract, construct of figured worlds.

This study integrated elements from each framework to consider how successful African American adults identify themselves within the figured world of mathematics. Mathematics is being viewed as a figured world because many of the beliefs about learning and doing mathematics are socially and culturally constructed. These constructions have resulted in an exclusive figured world considered only accessible to the academically elite (Boaler, 2016; Gutierrez, 2015). As such, a disproportionate amount of mathematics learners come to identify themselves as actors with relatively little influence, privilege, and power in this world (Holland et al., 1998).

I was interested in learning how everyday experiences and interactions within various communities of practice (e.g., classrooms, families, informal learning environments) during middle or high school contributed to participants' construction and endorsement of narratives related to their engagement (i.e., participation or non-participation) with mathematics. I also wanted to learn about the different sources that shaped their identification with mathematics. How salient were biological characteristics such as race and gender (N-identities) and how did they contribute to participants' self-understandings? What were the roles of institutions (e.g., school), discourses of socializing agents (e.g., parents, teachers, peers), and identification with certain affinity groups (I-, D-, and A- identities, respectively) in shaping the stories participants tell about

themselves related to mathematics? How did their identification with mathematics align or conflict with other aspects of their identities?

Identity Research Within Mathematics Education

Within mathematics education a number of researchers have examined identity construction and negotiation within (Anderson, 2007; Berry et al., 2011; Boaler, 2002; Boaler & Greeno, 2000; Martin, 2000) and outside (Martin, 2000; 2006, 2007; Nasir, 2002; Nasir & Hand, 2008) the mathematics classroom. The influences of Holland et al. (1998), Wenger (1998), Gee (2000), and Sfard and Prusak (2005) permeate the mathematics identity literature.

Defining Mathematics Identity

There is no agreed-upon definition across the mathematics identity literature (Diversity in Mathematics Education Center for Learning and Teaching, 2007; Darragh, 2016). Although the discipline lacks an agreed-upon definition, a common thread running through the mathematics identity research is the representation of identity as a construct influenced by several distinct, albeit interrelated, factors. Much of the literature (e.g., Anderson, 2007; Boaler & Greeno, 2000; Grootenboer & Zevenberg, 2008; Nasir & Hand, 2008) describes mathematics identity as individuals' self-perceptions related to mathematics based on their experiences and interactions in communities or environments such as mathematics classrooms. These self-perceptions are shaped by individuals' level of engagement in the practices of the community and how others perceive their participation. Martin (2000) offers a definition frequently cited in the mathematics identity literature: One's beliefs about "a) their ability to perform in mathematical contexts, b) the importance of mathematical knowledge, c) constraints and opportunities in mathematical contexts, and d) motivation and strategies used to obtain mathematics knowledge" (p.19). On the surface the definition appears to minimize the role of social interaction; however, it is part of a multilevel

framework examining contextual factors (sociohistorical, community, school, and intrapersonal forces) that influence the mathematics socialization and identity development of successful and unsuccessful African American adolescents. In later works Martin (2006, 2007) elaborates on this definition adding that mathematics identity is "expressed in narrative form" and "encompasses how others 'construct' us in relation to mathematics" (2006, p.206).

Mathematics Identity Development in Figured Worlds

Boaler and Greeno (2000) draw from Holland et al. (1998) positing that mathematics classrooms are figured worlds where teachers and students act as agents conducting rituals of practice, interpreting their actions and interactions, and developing self-understandings about their role or position in that world (i.e., identities). The researchers indicate that many mathematics classrooms are figured worlds that consist of highly structured rituals and procedures (Boaler & Greeno, 2000). While most students are capable of these practices, many of them eventually reject mathematics because their experiences in the mathematics classroom conflict with their developing identities as creative, thinking agents in other figured worlds (e.g., writing or the arts). In a study of AP calculus students, Boaler and Greeno (2000) found that the rituals and interpretations of experiences within contrasting figured worlds led students to develop considerably different self-understandings related to mathematics. Students who experienced didactic mathematics teaching practices and were given fewer opportunities to exercise agency or independent thinking reported more negative identifications with mathematics and less desire to continue pursuing upper level mathematics coursework than students who experienced classrooms where discussion and collaboration were encouraged.

Mathematics Identity Development in Communities of Practice

Wenger's (1998) influence can be found in the work of Nasir and Hand (2008) and Grootenboer and Zevenberg (2008). Nasir and Hand (2008) indicate that varying levels of participation in communities of practice across different contexts result in different levels of identification and engagement in the practices of those respective communities. In a comparison of support for engagement on a high school basketball team and in a high school mathematics class, the authors employ the term practice-linked identities to describe the identities individuals construct, embrace, and enact related to the practices associated with specific contexts or environments (Nasir & Hand, 2008). The researchers consider three aspects of participation in a community of practice—access to domain, integral roles, and opportunities to make a unique contribution and feel valued—that contribute to the development of practice-linked identities.

The authors found that participation on the basketball team provided increased opportunities for accessing the domain (i.e., understanding how the individual skills practiced fit into the overarching goals of the game), assuming a role integral to the work and success of the entire team, and inserting unique aspects of one's personality into their role on the team. The high school geometry classroom offered limited opportunities for identification and engagement with the mathematics. The teacher's didactic approach to instruction did not include connections between what the students were learning in class and how it fit into the 'big picture' (i.e., the domain) of mathematics. In addition, the class structure (independent seat work, call-and-response teacher questioning) did not offer many opportunities for students to assume integral roles or contribute unique aspects of their character within the classroom community. Consequently, students demonstrated stronger practice-linked identities in relation to basketball than mathematics, which had very different implications for the level of engagement across the two contexts (Nasir & Hand, 2008).

Grootenboer and Zevenbergen (2008) limit their focus to the classroom environment, describing mathematics classrooms as communities of practice with three significant components— teachers, students, and the discipline of mathematics. The teacher's key role is to support the development of positive mathematics identities in students, which they consider vital to bridging students and mathematics. The authors argue that fostering students' relationship with the subject requires practices that reflect the true nature of the discipline and work of mathematicians rather than presenting mathematics as disjointed procedures and facts. Their argument aligns with Nasir and Hand (2008) and their emphasis on accessibility of a domain as a contributing factor to the development of a practice-linked identity and levels of participation in different community practices. Grootenboer and Zevenbergen (2008) posit that while mathematics classrooms are temporal communities, the identities developed within them will endure and influence students' future engagement with mathematics. As such, teachers have a responsibility to facilitate practices and experiences with learning and doing mathematics that foster positive relationships with the subject.

Four 'Faces' of Mathematics Identity Development

Gee's (2000) influence is evident in Anderson's (2007) four 'faces' of mathematics identity: engagement, imagination, alignment, and nature. Engagement involves varying degrees of learners' interactions with mathematics content, their teachers, and their peers. Through these interactions learners come to see themselves and be seen by others as individuals who are or are not capable of learning mathematics. The engagement face of identity aligns with Gee's discursive identity (*D*-identity) which is influenced through interaction with and recognition by others as a certain type of person. Anderson's (2007) imagination face of identity refers to learners' ability to relate to mathematics and see how it fits into the broader experience of life (e.g., other activities,

interests, or goals). Identification through imagination bears resemblance to Gee's affinity identities (*A*-identities) which develop from shared interests with others. Students who view mathematics as an integral part of their lives may associate their own behaviors with those of other individuals they consider to be 'math people'. This association may foster the development of positive mathematics identities. The alignment face of identity is comparable to Gee's institutional identity (*I*-identity). Alignment refers to students' investment in mathematics based on institutional requirements or boundaries (e.g., some students enroll in advanced mathematics classes in preparation for college while others elect out of advanced coursework because they do not plan on attending college) (Anderson, 2007). The degree of students' alignment with institutional requirements will lead them to see themselves and be recognized by others as certain types of mathematics learners. Anderson's nature face of identity (2007) is taken directly from Gee's *N*-identities (2000). Both researchers define nature identities as innate characteristics individuals such as gender or skin tone. The significance of nature of identities depends on their salience in environments where interactions with others occur. With respect to the nature face of identity, Anderson (2007) refers to a fallacy held by many students and parents about the existence of a 'math gene' that some individuals are born with and most are not. This erroneous belief was expressed by several participants in his research with high school students and impacted their perception of who could be considered a math person.

African American Learners and Mathematics

Identity Negotiation

Students are constantly negotiating multiple identities while learning mathematics. Racial, gender, social, and mathematics identities contribute in varying degrees to learners' engagement and achievement in mathematics. At times these identities come into conflict, requiring students

to reconcile contradictions between them (Fordham & Ogbu, 1986; Martin, 2000; Martin, 2006; Nasir & Saxe, 2003; Ogbu, 2002). Tension between different aspects of a learner's identities can arise from factors such as conflicting messages received about the importance of mathematical knowledge, the types of mathematical knowledge or practices that are privileged, and for whom formal mathematical knowledge is accessible (Berry et al., 2011; Diversity in Mathematics Education Center for Learning and Teaching, 2007; Martin, 2000, 2006). These messages may originate from individuals in their immediate circle of influence or from more distant socializing agents such as popular media (Young et al., 2017). Martin (2000) interviewed 35 successful male and female African American adolescents in a junior high school where large numbers of African American students underperformed in mathematics. Afterwards he notes that students received mixed messages from teachers, parents, and peers about the importance of education and mathematics. He goes on to discuss how, unlike their lower performing peers, successful students were able to navigate through conflicting messages, using positive messages as a source of strength and motivation to persist while disregarding negative messages with attitudes such as "Kick it out of the way and keep on going" (pp. 122-123).

Learning Mathematics While Black

Learning mathematics can be a racialized experience for African American learners (Berry et al., 2011; Martin, 2006, 2007, 2009; Nasir & Shah, 2011; Stinson, 2008). Longstanding racialized narratives about African American learners' academic abilities—particularly related to mathematics—along with the persistent racial achievement gap, have led to a belief that *African Americans are not 'math people'* (Berry et al., 2011; Delpit, 2012; Martin, 2000, 2006, 2007; Nasir & Shah, 2011). The perception of African Americans as less capable in mathematics exists in the minds of some educators, influencing how they perceive and respond to African American students

(Berry, 2005, 2008; Martin, 2006; Nasir & Shah, 2011). After synthesizing studies on stereotype threat and race and mathematics, Nasir & Shah (2011) report that African American males articulated complementary racialized narratives they had to negotiate related to academic achievement- 1) "African Americans are not good at school and/or math"; and 2) "Asian students are good at school and/or math" (p. 30). Accepting these narratives as "fact" can lead teachers or other school staff members to implicitly or explicitly communicate low expectations for their performance, a phenomenon reported by African American students (Martin, 2006; Nasir & Shah, 2011). Some African American learners, having internalized messages of low ability or low expectations, disengage from mathematics and ultimately behave in ways that reinforce and perpetuate those stereotypical beliefs (Delpit, 2012; Martin, 2000, 2006). However, many African American students choose to resist the narratives, consciously defying negative perceptions and low expectations to persist and excel in mathematics (Delpit, 2012; Martin 2000, 2006, 2007).

Martin (2006, 2007) synthesizes several years of research examining the experiences of African American adults who recalled the salience of race while learning mathematics during their K-12 school years. His participants were non-traditional community college students enrolled in mathematics courses such as Algebra, Pre-Calculus, and Differential Equations. These individuals elected to re-invest in mathematics in adulthood for a variety of reasons including career advancement, being able to assist their children with mathematics, or to prove to themselves that they could learn and do mathematics. Several participants describe earning high marks and enjoying mathematics in the lower grades then being denied access to upper level mathematics courses in middle and high school and discouraged from pursuing careers that required mathematics. Participants shared how those barriers led them to disengage from the subject in middle or high school despite recognizing the importance of mathematical knowledge.

In a study of academically and mathematically successful African American male adolescents, Berry (2005, 2008) reports on several participants who initially encountered elementary teachers who failed to recognize their academic potential. The teachers assigned narratives that cast the students as disruptive, immature, or otherwise not prepared for advanced placement. Their parents had to forcefully advocate for their sons' to be evaluated for placement into advanced courses after school officials underestimated their potential. While the boys later thrived in advanced mathematics classes in upper elementary and middle school, Berry (2008) reports that, at times, they still experienced interactions that created a sense of 'otherness' within their mathematics classrooms.

Supporting Positive Identification with Mathematics

Supportive experiences and interactions can bolster students' motivation and persistence to learn mathematics despite obstacles. Common themes have emerged as researchers explore factors supporting mathematics success or positive mathematics identity construction among African American learners. These factors include support, expectations, and experiences received from parents (Berry; 2005, 2008; Berry et al. 2011; Borum & Walker, 2011; Ellington & Frederick, 2010; Martin, 2000; McGee & Pearman, 2014), supportive interactions with role models such as family or community members (Berry et al. 2011; Borum & Walker, 2011; McGee & Pearman, 2014; Stinson, 2008); positive interactions with caring teachers (Berry et al. 2011; Borum & Walker, 2011; Ellington & Frederick, 2010; Martin, 2000; Stinson, 2008), interactions with like-minded peers in school or extracurricular programs (Berry et al., 2011; Martin, 2000; Stinson, 2008), and access to advanced coursework and/or extracurricular activities that offered exposure to rigorous mathematics (Berry 2005, 2008; Berry et al., 2011; Borum & Walker, 2011; Ellington & Frederick, 2010).

The Intersection of Race and Gender in Mathematics

Historically mathematics has been a space that is primarily white and male (Joseph, Hailu, & Boston, 2017; Stinson, 2013). Therefore, it could be argued that African American females have two "strikes" against them on the path to becoming learners and doers of mathematics. However, mathematics achievement data (e.g., NAEP) (Young et al., 2017), college completion data (McDaniel et al., 2011), and reporting on earned STEM degree/certificates (U.S. Department of Education, 2017) reveal that African American females are the only group to consistently outperform males in their racial subgroup. These trends suggest that African American males and females have differential experiences related to mathematics during the K-12 and postsecondary years of schooling.

Martin's research on African Americans' identification and engagement with mathematics (2000, 2006) includes perspectives from both African American males and females. However, much of the other research examining the intersection of race and gender in mathematics explores the experiences of *either* African American males *or* African American females. In the studies discussed throughout this review, for example, Berry (2005, 2008), Berry et al. (2011), McGee and Pearman (2014, 2015), Nasir and Hand (2008), Nasir and Shah (2011), and Stinson (2008) limit their focus to the experiences of young African American males. Studies reporting on African American females in mathematics include Borum and Walker (2011), Jones (2012), Joseph and colleagues (2017), and Moody (2003, 2004). One collective limitation of these studies is that they do not bring African Americans who identify as male and female together (e.g., in focus groups) to discuss and reflect on the commonalities and differences of their experiences. This study aimed to contribute to this area by conducting a heterogeneous focus group interview regarding mathematics experiences during adolescence.

Conceptual Framework

Martin (2009) calls for additional research that provides counter-narratives to dominant discourses about African American, Latino American, and Native American students being mathematically illiterate. This study attempted to respond to that call by sharing the stories of African Americans who leveraged mathematical knowledge to achieve success in their chosen career. Martin (2006, 2007) and other researchers (e.g., Berry, 2005, 2008, Nasir & Shah, 2011; Stinson, 2008) have taken a critical approach to examining African Americans' experiences with mathematics. Given the salience of race in educational outcomes, one would be misguided to approach the subject of African Americans and mathematics without somewhat of a critical lens. This project is not foregrounded in critical race theory (CRT); rather, it sits on the periphery. There is much worth in a critical examination of the structural barriers encountered by African American mathematics learners and resulting outcomes; nevertheless, this project emphasizes experiences that bolstered African Americans in regards to mathematics. The study does, however, apply the CRT tenet of giving voice to members of marginalized groups and offering counterstories to the dominant narrative (Ladson-Billings, 1998; Ladson-Billings & Tate, 1995; Tate, 1997).

While there is a large volume of existing literature, it was challenging to find well-developed frameworks conceptualizing mathematics identity. Martin (2000) offers a multi-level framework that considers sociohistorical, school, and community forces individuals negotiate during their mathematics socialization. Visually the framework uses a word web to represent individuals' exercising of agency (i.e., "resisting, conforming, making decisions, and forming beliefs and dispositions" (p. 33)) as they encounter forces, opportunities, or constraints during the construction of mathematical knowledge and identities. The framework is insufficient for this project because it does not provide enough differentiation between the types of community forces that can contribute to individuals' mathematics identities.

Anderson (2007) equates and represents the four faces of identity with the four faces of a tetrahedron. Each face represents different aspects of how students see themselves in relation to mathematics. He argues that teachers and students should discount nature and build on the other three faces (engagement, imagination, and alignment) to foster positive mathematics identities. One limitation to this framework is that it appears to limit the construction of mathematics identity to interactions and experiences that occur in schools and mathematics classrooms.

In order to carry out this inquiry, I developed a new framework for conceptualizing mathematics identity development. The original conceptual framework for this project (see Figure 1) integrated Wenger's (1998) communities of practice, Holland and colleagues' (1998) figured worlds, and Sfard & Prusak's (2005) collection of reifying stories with Martin's (2000) definition of mathematics identity. Concentric figures were used to represent the experiences and beliefs that collectively contribute to how learners come to relate to the figured world of mathematics. The narratives individuals develop about themselves as learners and doers of mathematics (i.e., mathematics identity) are shaped by their experiences and interactions with different socializing agents across various communities of practice. Identification with mathematics is assumed to impact engagement; therefore, those experiences and interactions could mediate how learners participate in the figured world of mathematics.

Gee's (2000) four aspects of identity were intentionally left out of the framework. I anticipated (based on existing research and personal experience) that participants would share stories demonstrating that characteristics such as race or gender (*N*-identities) resulted in experiences with some individuals who imposed identities rooted in negative assumptions about those characteristics (i.e., institutional or discursive identities). Additionally, I anticipated participants reporting that shared experiences with like-minded individuals (affinity identities) within certain communities of practice provided emotional or academic support. However, I did

not want to go into the project imposing my experiences and specifically "looking for" those factors when they might not have been salient for the participants.

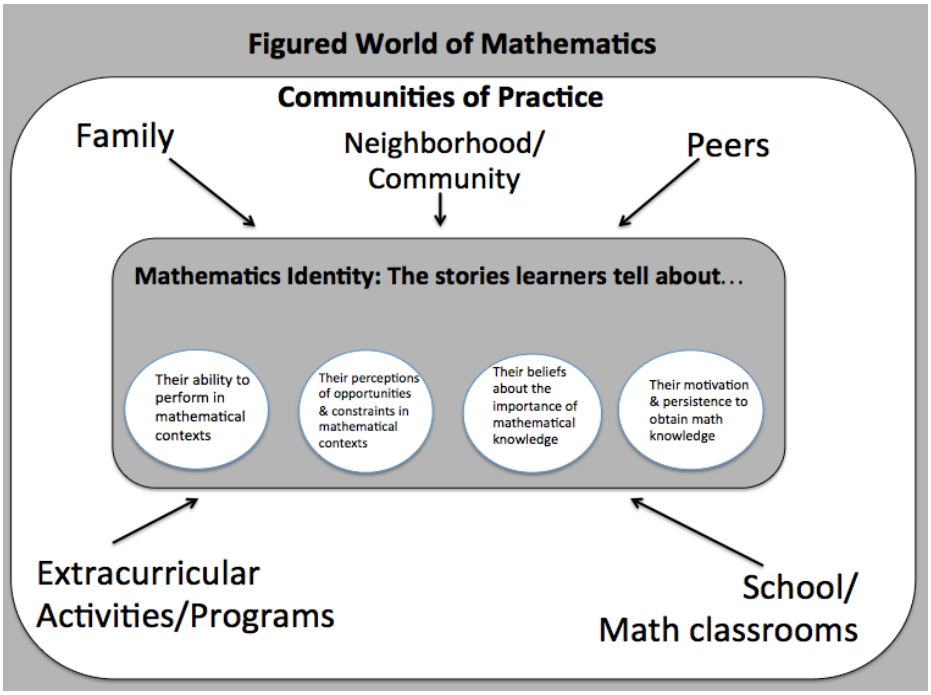

Figure 1. Original Conceptual Framework

After data collection and analysis, the conceptual framework was revised (see Figure 2) to better reflect the themes that emerged from the data collected. The framework continues to integrate Wenger's (1998) communities of practice, Holland and colleagues' (1998) figured worlds, and Sfard & Prusak's (2005) collection of reifying stories with an adaptation of Martin's (2000) definition of mathematics identity. Additionally, the shapes that represent the practices and interactions contributing to the development of an individual's mathematics identity are still situated within a larger shape that represent the figured world of mathematics. The figured world of mathematics, a realm with required entry during the K-12 school years, consists of a language of numbers, symbols, and operations. This language is learned as individuals engaging in activities, discourses, and performances related to mathematics. Individuals learn and apply the language of the figured world of mathematics within various communities of practice such as home, school,

and extracurricular programs or activities. The activities, discourses, and performances within the figured world of mathematics occur through interactions with socializing agents such as parents, teachers, and peers. The degree of participation (inclusion or marginalization) within communities of practice and the messages and expectations communicated through interactions with socializing agents contribute to an individual's perception of their degree of mastery, agency, and influence in the figured world of mathematics. These self-perceptions shape the stories individuals tell about their mathematics identity. After analysis of the data, mathematics identity was condensed from four aspects to three because I found a lot of overlap between beliefs about the importance of mathematical knowledge and perceptions of opportunities and constraints in mathematical contexts. Aspects of Gee's aspects of identity (nature, institutional, discursive, and affinity) were found within the data but they were not salient enough across participants' experiences to warrant inclusion in the conceptual framework.

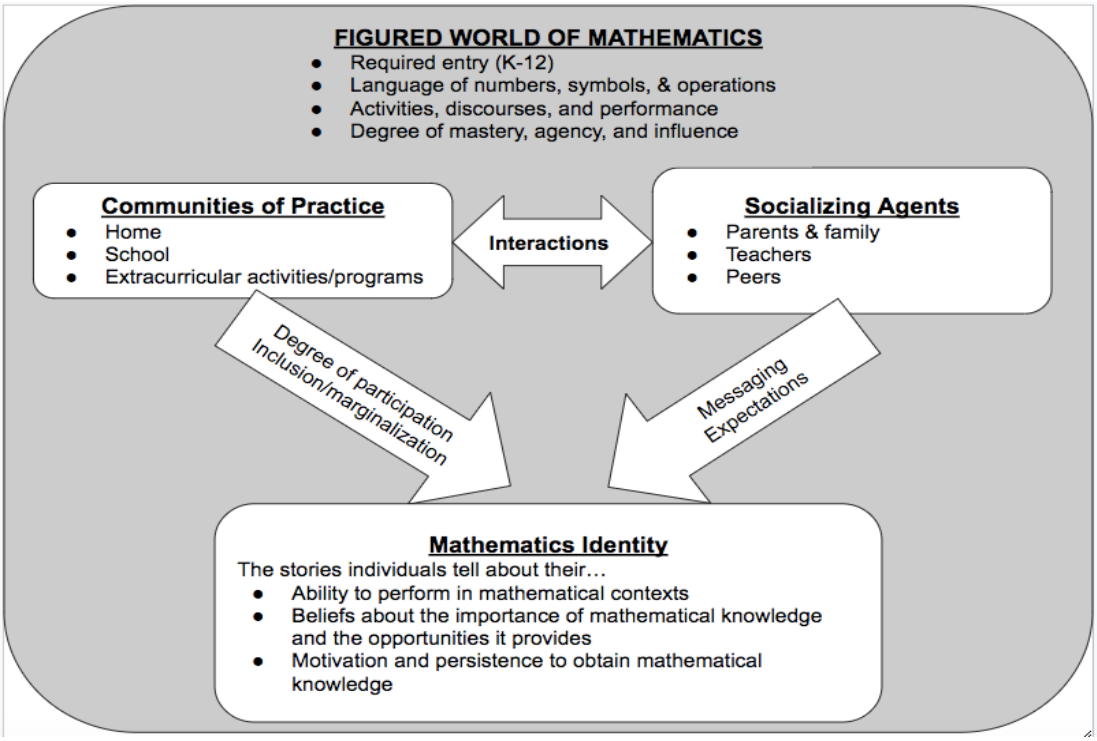

Figure 2. Revised/Final Conceptual Framework

Summary

This chapter began with an introduction of four frameworks for considering identity as a theoretical lens in educational research along with a discussion of how they contributed to the theoretical framework for this study. The frameworks were Wenger's (1998) identity in practice, Holland and colleagues' (1998) identity within figured worlds, Gee's (2000) identity as recognition as a "certain type of person," and Sfard and Prusak's (2005) identity as a collection of reifying, endorsable, and significant stories. The frameworks were followed by a synthesis of seminal research on mathematics identity before shifting the focus to research on mathematics identity development among successful African American learners. The chapter concluded with an explanation of the original and revised conceptual frameworks that emerged from this project to explore the experiences of African Americans working in STEM-related careers.

Chapter 3 METHODOLOGY

Overview

This study used narrative inquiry to examine the mathematics identities of successful African Americans and the experiences during adolescence that supported positive identification with mathematics. For this project success was defined as working in a STEM-related occupation for a minimum of two years. Four research questions were used in this inquiry: 1) *What stories do successful African Americans tell related to their mathematics identities and engagement with mathematics?* 2) *What interactions, experiences, and practices during adolescence contributed to the development of their mathematics identities?* 3) *How did the construction of participants' mathematics identities align with or contradict the construction of their other identities? How did they negotiate any contradictions?* 4) *What foundational mathematics concepts and skills do participants highlight as useful for being prepared to pursue the training necessary for their careers?*

This chapter begins with a rationale for the selection of narrative inquiry for this project. The rationale is followed by a description of the recruitment process and participant selection criteria, along with ethical considerations. Data collection and analysis procedures are described before concluding with a discussion of trustworthiness.

Rationale for Narrative Inquiry

A qualitative research approach is most appropriate when researchers seek to understand some aspect of the world from other individuals' points of view while considering the physical, social, and cultural contexts that shape and are shaped by those perspectives (Maxwell, 2013).

Among the most common qualitative research approaches, narrative inquiry is best for exploring the lived and told stories of individuals, as these stories can shed light on their identities (e.g., how they perceive themselves) and their experiences (Creswell & Poth, 2017). Clandinin (2013) describes narrative inquiry as "an approach to the study of human lives conceived as a way of honoring lived experiences as a source of important knowledge and understanding" (p. 17). Narrative research methods allow researchers to capture detailed stories or life experiences of one individual or of a small number of individuals (Creswell & Poth, 2017). Given my desire to learn more about the nature of experiences and contexts in which a small group of successful African Americans developed positive mathematics identities, I chose to use a narrative approach when designing this project.

Participants

While narrative inquiry can involve in-depth examination of one or two individuals, I elected to interview ten people with the hope of uncovering shared experiences or a collective story (Creswell & Poth, 2017). Targeted occupations included accounting, education, engineering, healthcare (e.g., nursing, medicine, pharmacy, dentistry), information technology (IT), and trades (e.g., carpentry, plumbing, electrical). To ensure that individual professions were not overrepresented in the small sample of participants, I recruited for a general diversity of occupations. I was willing to exceed the targeted number of participants up to 15 to be inclusive of several different STEM-related occupations; however, it worked out that the first ten participants worked in a variety of positions. The following professions are represented in this study: engineering (electrical and chemical), product manufacturing, information technology (IT), economics, research in the health sciences, and education.

Participants were recruited between the ages of 20 – 42. The rationale for this delimitation was to limit the timeframe since exiting high school to less than 25 years with the hope that participants' memories would be more vivid than if they had been out of high school for longer. The lower age limit of 20 was based on the definition of success for this project. Assuming a high school graduation age of 18, an individual would be 20 years of age by the time they had worked in their occupation for a minimum of two years. Ultimately, the participants ranged in age from 23 to 41 at the time of data collection.

A combination of purposeful and snowball sampling was used to recruit ten African Americans from STEM-related occupations. These sampling methods were chosen with the goal of recruiting individuals who could serve as information-rich cases to explore the research questions (Creswell & Poth, 2017; Maxwell, 2013). I drew on my professional and social networks to identify potential study participants. Information about the project was shared by word of mouth (e.g., conversations with peers, colleagues, and acquaintances) and the distribution of electronic and printed copies of a recruitment flyer (see Appendix A). As part of the recruitment process I reached out to friends and colleagues who are members local chapters of Greek organizations (i.e., sororities and fraternities) and asked them to distribute the recruitment flyer to other members. An additional strategy which helped identify potential participants was the inclusion of a question on the individual interview protocol which asked current participants if they knew other individuals who might be interested in the study (see Appendix D). Ultimately, six African Americans who identified as female and four who identified as male participated in the study. Table 1 provides demographic information about the study participants.

Table 1

Participant Demographics

Pseudonym	Gender Identification	Age	Occupation	Years in their Field
Ariel	Female	40	Engineer: Director	18
Brianna	Female	33	Education Specialist	12
India	Female	40	Economist	17
Keisha	Female	41	Researcher/Assistant Professor-Clinical Laboratory Sciences	9 (6 in a lab setting, 3 as assistant professor)
Natalie	Female	39	IT Project Manager	11
Sable	Female	40	Lab director	19
Bryce	Male	23	Secondary mathematics teacher	2
Calvin	Male	39	Production Manager	17
Damian	Male	39	Systems Engineer	19
Thomas	Male	38	Traffic Engineer	10
TOTAL *N* = 10	F = 6 (60%) M = 4 (40%)			

This study was intended to be unique in its inclusion of individuals from trades in the definition of STEM-related occupations and success. I was aware, when making the decision, of the dichotomy that exists in our society between professional (i.e., white collar) jobs and trades (i.e., blue collar work) in terms of defining "success". Success is often associated with white collar professions that require formal postsecondary education. Because of this conditioning in society, there was a possibility that some individuals who work in trades would not consider themselves to be successful. I did not know if a participant working in a trade would feel that they ended up in their occupation because other options were closed off to them. Such a finding ran the risk of upholding the dichotomy between professions and trades; however, I felt it was important to be inclusive when studying mathematics identity among African Americans. Many of the previous studies with adult participants focus on college students or graduates which privileges their voices and perspectives over African Americans who chose to follow a different path. Unfortunately, I

was not able to explore these issues in this project because I was unable to secure any participants who worked in a trade. During the recruitment process I made several attempts to contact two national professional organizations for African American contractors; however, my emails and messages went unanswered. I also attempted to recruit several individuals through mutual friends; however, scheduling issues or a reluctance to be interviewed prevented them from joining the study.

Ethical Considerations

Informed Consent and Confidentiality

During the recruitment process, I shared electronic or printed recruitment flyers with potential participants (see Appendix A), explaining the purpose of the study and potential benefits from the findings. The Institutional Review Board determined the study to be exempt from full review; therefore, it did not require the collection of signed consent forms. Instead participants were provided a one-page study information sheet (see Appendix B) that explained the purpose of the study and what participation would entail. Not having to collect and store signed consent forms offered participants one layer of confidentiality. To further protect their confidentiality, each participant was assigned a pseudonym for data analysis and reporting. The identifying forms collected from participants—Participant Information and Math History Form (see Appendix C)—are stored in a secure location and only accessible to the researcher, committee members, and if necessary, the university Institutional Review Board. Electronic files which include audio and video files, transcripts from the individual and focus group interviews, and participant profiles are stored on an encrypted computer and uploaded to a secure university server. Additionally, participants' names were replaced with their pseudonyms in the interview and focus group transcripts and participant profiles.

Research relationships

My decision to examine the experiences of successful African Americans within my age group means that some of my peers were eligible to participate in the study. In planning this project, I spent time reflecting on whether including peers as participants could compromise the findings. Ultimately, I decided that, while I would make concerted efforts to recruit individuals I did not know, I should not exclude individuals who could serve as rich cases because of pre-established relationships. In the end, five of the study participants were individuals I knew prior to the study and five were individuals I did not know.

Blichfeld and Heldbjerg (2011) argue that interviewing friends or acquaintances can add openness, honesty, and trust to an interview. They point out that seeking informants who researchers do not know is rooted in the positivist pursuit of obtaining objective knowledge. For research based on the belief that human knowledge is subjective and meaning is constructed in collaboration, there are instances where interviewing acquaintances may offer advantages over interviewing strangers (Blichfeld and Heldbjerg, 2011). Furthermore, Adler and Adler (2003) state that researchers' relationships with participants can help overcome reluctance or resistance to respond during interviews. Therefore, a level of familiarity with some participants could help them feel more comfortable being transparent while sharing their personal experiences.

It was possible, however, that reflecting on past experiences could stir up negative emotions or vulnerabilities that would be easier to share with someone who a participant was not worried about seeing on a regular basis. One strategy for balancing this tension was to follow a semi-structured interview protocol with all participants rather than conducting unstructured interviews which could have potentially felt like, or turned into, a chat between friends. Additionally, at the beginning of the individual interviews and focus group discussion, I emphasized to participants that they did not have to answer any questions that made them

uncomfortable. Finally, I made a concerted effort to refrain from filling long pauses or lulls in the discussion with my own stories or experiences, something I typically do in casual conversations. By adhering to the interview protocol, giving the option to decline to answer questions, and refraining from interjecting my own experiences into the discussion, I believe I provided the participants with preestablished relationships a degree of separation between participating in a research interview and having a conversation with a peer.

Research Design

Data Collection

Data collection consisted of semi-structured individual interviews and one structured focus group discussion composed of four participants. The individual interview protocol and focus group discussion guide can be found in Appendices D and E, respectively. Questions were developed with the goal of eliciting a series of stories from participants about their experiences related to mathematics during their middle and high school years and how those experiences contributed to their self-perceptions as learners and doers of mathematics. One strategy for dealing with the passage of time was to word interview and focus group questions with the phrase "in middle/high school" to alleviate the burden of participants' having to provide specific times and places related to their experiences.

Individual Interviews. All ten individual interviews were conducted by phone at the participants' convenience and ranged in length from 25 - 45 minutes. Each interview was recorded on an iPhone using the TapeACall application from the Apple app store. It would have been preferable for interviews to take place in-person; however, time and geographical constraints made the in-person request inconvenient for these busy professionals with families. In addition to

recording the interviews, I took written notes to capture stories or ideas for follow up questions or additional discussion.

Prior to their interview, each participant completed a Participant Information and Math History Form (see Appendix C). Information gleaned from the forms was referenced during the individual interviews and incorporated into the focus group discussion. In addition to providing me with information about the participants' backgrounds, completion of the form helped prime their memories by getting them think about their math experiences in middle or high school. Two of the participants indicated that they looked at "old" documents (e.g., high school transcript, school yearbooks) to help refresh their memories.

Focus Group Discussion. Focus group interviews provide opportunities for individuals with similar backgrounds or experiences—related to the research issue—to share personal experiences, hear the experiences of others, and reflect on issues in light of those discussions (Hennink, 2014). Additionally, focus groups have the potential to reveal "collective narratives" that extend beyond the perspectives or experiences of an individual (Hennink, 2014). The use of focus groups is recognized as a research method that "gives voice" to groups of individuals who may not otherwise be heard (Carey & Asbury, 2012). As such, they are considered a culturally anchored research method (Hughes & DuMont, 1993). The social interactions that take place in focus groups can reveal shared cultural knowledge or experiences while also illuminating the range of experiences among members of a group (Hughes & DuMont, 1993).

The focus group session for this project gave successful African Americans who work in STEM-related occupations an opportunity to share and discuss their adolescent experiences related to mathematics. Given the retrospective nature of this study, I hoped that hearing the experiences of other individuals would spark additional memories that did not come up during the participants' individual interviews. Statements throughout the transcript (e.g., "I concur"; "I would echo what

a lot people already said"; "So to piggy back on something that Damian mentioned earlier…") suggests that hearing other participants' stories did, in fact, evoke memories they had not recalled during the individual interview. A second goal in using focus groups was to see whether a set of collective experiences emerges from successful African Americans with regards to positive identification with mathematics. The collective themes that emerged from the data will be discussed in the following chapter.

The focus group discussion took place after all individual interviews were complete. Multiple sessions were offered to accommodate participants' schedules and to keep group sizes small. Small groups give participants adequate time to share their perspectives, which helps facilitate in-depth discussion (Hennink, 2014; Hughes & DuMont, 1993). I planned to host one weekend daytime session and a weekday evening session; however, the weekend session proved inconvenient for many participants. As with the individual interviews, in an ideal situation, all members of the focus group session would have met in-person. Four of the study participants live in different states, however, so an option was given to join the discussion online. Ultimately, I ended up hosting one weekday evening session with four (2 male, 2 female) participants. The session took place in a study room in the library of a local university with two participants attending in-person and two joining the discussion via Google Hangout. A fifth participant planned to join the session online but technical difficulties left her unable to access the Google Hangout. The session was digitally recorded on a MacBook Air using the screen record feature of Quicktime Player. I also used the voice memo app on my iPhone to capture an audio recording of the discussion as a backup file.

A structured discussion guide (see Appendix E) was used to keep the group discussion focused on issues pertinent to the study (Hughes & DuMont, 1993). The session lasted approximately 60 minutes. Within that timeframe each participant was given 1-2 minutes to

introduce themselves to group, 5 to 10 minutes was spent on each discussion question, and each participant was given 2-3 minutes to share closing thoughts at the end of session. Participants who completed both the individual interview and focus group discussion received a $10 Subway gift card as a thank you for their time. The fifth participant who was unable to connect to the focus group Google Hangout was also given a gift card as token of appreciation for her involvement in the study.

Data Analysis

Data analysis was an iterative process that involved multi-stage thematic coding (deductive and inductive), analytic memoing, and construction of a participant matrix (Miles, Huberman, & Saldana, 2013). At the conclusion of data collection, the digital recordings of the individual interviews and focus group discussion were sent to a transcription company to be transcribed verbatim in Microsoft Word. While the files were out for transcription, I used Microsoft Excel to create a participant matrix (see Appendix F) that summarized the information collected from the Participant Information and Math History Forms.

Upon receiving the completed transcriptions, I printed copies to follow along and edit as I listened to each audio file. Since I did not perform the transcriptions myself, checking the typed transcripts against the audio files allowed me to start getting close to the data. I also used this stage of the process to remove identifying information, correct typos in the transcripts, and fill in "holes" where the transcriber was unable to decipher certain words or phrases that I, as the interviewer, recalled or understood. After listening to the files and editing the documents in MS Word, I printed clean, updated copies of the transcripts and began coding and highlighting big ideas on paper. During this process I added new codes and subcodes to my provisional "start list" of codes (see Appendix G) which had been informed by studies synthesized in the review of literature and the

original conceptual framework for the study (see Figure 1) (Miles et al., 2013). My provisional coding scheme was limited (e.g., Gee's *N*-, *I*-, *D*-, and *A*-identities were not originally represented) to reduce the risk of imposing preconceived notions onto the data. However, if those themes emerged during data analysis, the codes were added as appropriate.

The interview and focus group transcripts and Math History Forms were used to write a mathematics biography (i.e., narrative profile) for each participant, which served as an additional aspect of data analysis and interpretation. The individual interview transcripts, mathematics biographies, and focus group transcripts (where applicable) were shared with participants to review and verify that their perspectives and experiences were represented accurately (Maxwell, 2013).

After going through two cycles of coding on the printed transcripts and writing the participant profiles, I uploaded the electronic transcripts for coding in the qualitative data analysis software, ATLAS.ti. Moving to the software program made it easier (and neater) as the coding scheme evolved (i.e., codes/subcodes were added, revised, or deleted) to accommodate themes that emerged through several cycles of coding. The final coding scheme is shown in Table 2.

In additional to multi-stage thematic coding, I used ATLAS.ti for creating a series of analytic memos which captured my thoughts, synthesis of information, and evolving interpretations of themes in the data. Topics of the analytic memos included theoretical framework, data analysis, utility of math, socializing agents, African American identity, and future ideas/limitations.

Table 2

Final Coding Scheme

Category	Codes	Subcodes
Occupation	Current occupation Preparation/training How math is used	

	Representation Early Interest	
Math Identity	Ability to perform/current comfort level Affirming experiences Importance/opportunities Motivation & persistence Messages to others	
Other Identities	Student Identity Race/gender/peer group	
Communities of Practice	School	demographics tracking
	Home	
	Extracurricular programs/activities	School-related activities Summer programs Other out-of-school activities
Socializing Agents	Parents/family Peers Teachers	
Messaging	General academics	
	Math specific	Parents/family Teachers
Expectations	Parent expectations Peer expectations Teacher expectations Overcoming stereotypes	
Support	Parents/family	Math backgrounds Helping peers
	Peers	Receiving help Positive peer pressure
	Teachers	Teaching style Classroom environment Extra help
Math_Figured World	Nature of math Connection to Science Foundational math	

Trustworthiness

Issues of trustworthiness in qualitative research are analogous to validity and reliability threats in quantitative research; therefore, qualitative researchers have a responsibility to address potential biases in a study before, during, and after data collection (Bloomberg & Volpe, 2016; Maxwell, 2013). I am an African American woman working in a STEM-related occupation.

Currently I am the Coordinator for Assessment and Remediation for a middle school, a role that involves a lot of data analysis. I have vivid memories of experiences that impacted my self-perceptions related to mathematics during adolescence. Throughout this research I recognized that if not acknowledged and addressed, I ran the risk of imposing my perceptions of my own experiences onto the participants' stories. It was important that I guarded against painting successful African Americans with the same brush, so to speak. For example, I never encountered an African American math teacher in middle and high school. Additionally, race was particularly salient in some of my classes and the expectations communicated to me by certain math teachers. However, this experience was not the case for all the participants. To keep my biases in perspective I maintained a research journal throughout data collection, data analysis, and the process of writing up the findings (Bloomberg & Volpe, 2016). The journal includes personal reflections, "aha" moments, and analytic memos detailing the evolution of the coding schemes and my interpretations of the data.

Several additional strategies were employed to reduce bias. First, interviews were transcribed verbatim to capture all information shared by participants rather than subjectively including or excluding data from analysis (Maxwell, 2013). Verbatim transcripts ensure that discrepant data is included and addressed in the analysis process. Next, information provided in the Participant Information and Math History Forms, individual interviews, and focus group interviews was triangulated to confirm consistency among participants' accounts of their experiences. Beyond triangulation of data sources, it was not possible to determine if participants were completely forthcoming about their experiences. Interviewing other individuals (e.g., parents, peers, siblings, former teachers) who could verify or corroborate their stories was beyond the scope of this project. My hope is that the emphasis on participants' representation of successful African Americans helped them feel comfortable being open and honest about their adolescent

experiences. As the facilitator of the interviews, I was cognizant of providing participants with a safe environment where they could tell their stories confidentially and without judgement. Third, I used member checks to ensure participants' stories were accurately represented (Maxwell, 2013). I shared individual and focus group transcripts along with a narrative profile (math biography) with each participant, giving them an opportunity to provide feedback about my interpretations and conclusions. All ten participants responded to the member check, confirming that the stories they shared were accurately reflected in the profiles. Finally, in reporting the findings, I relied heavily on direct quotes from participants rather than summarizing their perspectives in my own words.

Summary

The purpose of this chapter was to describe the research methodology used to examine successful African American adults' and the experiences and interactions that supported the development of positive mathematics identities. The chapter began with a justification of why narrative inquiry was the best approach for this project. This justification was followed by descriptions of the participant selection criteria and recruitment process. After a discussion of ethical considerations, data collection procedures were explained. The iterative process of data analysis was discussed and the final coding scheme was presented. The chapter concluded with a discussion of issues of trustworthiness.

Chapter 4 FINDINGS

Overview

This chapter consists of a presentation of the study findings related to the four research questions. It begins with an introduction of each participant in order to provide background information about their occupations and adolescent experiences. Following the participant introductions, their stories (i.e., the findings) are presented as they relate to the four research questions: 1) *What stories do successful African Americans tell related to their mathematics identities and engagement with mathematics?* 2) *What interactions, experiences, and practices during adolescence contributed to the development of their mathematics identities?* 3) *How did the construction of participants' mathematics identities align with or contradict the construction of their other identities? How did they negotiate any contradictions? and* 4) *What foundational mathematics concepts and skills do participants highlight as useful for being prepared to pursue the training necessary for their careers?*

Within the presentation of the findings, themes that emerged from the data are introduced as headers for subsections for three of the four research questions. These themes emerged as the provisional coding scheme (see Appendix G) expanded and was then condensed into the final list of codes (Table 2, Chapter 3). These themes are unpacked and further explored in Chapter 5. The revision of the curriculum framework is also discussed further in the following chapter. Collective themes did not emerge within the data for Research Question 3; therefore, those findings are presented by participant. Decisions about the organization of the findings were driven by a desire

keep the participants' stories intact. Chopping up quotations to make them "fit" in a specific box would have taken away from the context and richness of participants' stories.

Participant Introductions

Clandinin (2013) states that "narrative inquiry is sometimes characterized as a methodology of personal experience (p. 33). She also suggests that we must understand the contexts (e.g., social, familial, institutional) that shape, and are shaped by, individuals and their experiences. Before presenting their stories as they relate to the aims of this study, they are each introduced below. The introductions are intended to share where they are today (i.e., how they have been "successful") and to offer context for the stories they shared about their adolescent experiences.

Female Participants

Ariel. Ariel, 40, has a Bachelor's Degree in Chemical Engineering, and has worked in her occupation for 18 years in a variety of roles. At the time of her interview, she was preparing to transition into a new role as a Director of Engineering. Ariel grew up in a southeast coastal state, attending middle and high school in a public rural school district with four high schools. She estimated there were 125 students in her graduating class. In terms of diversity, her middle school was evenly split between African American and Caucasian students. The demographics shifted slightly in high school; approximately 15% of the student population was Native American while the remaining 85% was an even split between African American and Caucasian students.

Students were placed on academic tracks at both the middle and high school levels. Ariel's classes were on the advanced track. She took Algebra 1 in the 8th grade. Her high school math course sequence included Geometry, Algebra 2, Algebra 3, and Precalculus, respectively. She reported having two African American mathematics teachers, one male and one female. When

asked about the demographics of the advanced math classes compared to the school population, she indicated that African American students "were slightly underrepresented, but not by much."

Ariel described herself as a "high performer" in middle and high school with math being the subject she enjoyed the most. "I think I took every single math course they offered (laughs). Unfortunately, they didn't get all the way to calculus at my high school, but they offered a few additional math courses that I took." She excelled in her advanced mathematics courses, stating-

> I will be quite honest. I did not have any difficulty in middle school or high school with math. I did have trouble in college but (laughs) – not in middle school or high school. It's just – I don't know. It wasn't difficult at all.

Ariel did, however, share a challenge that came from growing up in a rural area as she described her journey to engineering-

> I think being in a more rural school, I think people just didn't know what else was out there. You know, a lot of people only know what they see and so I think my challenge was kind of knowing what else was out there, what I could do and so I really just fell into engineering just by happenstance. I don't think anybody, counselors or you know, even my teachers really pushed on going into engineering…I fell into engineering because [the college I ended up attending] solicited me and said "hey, come to this new program, engineering", my parents said "oh, engineering. Scholarship. That sounds good. You go there" (laughs), you know? I was actually going to do like computer science or something like that at a North Carolina school that I had gotten a scholarship for.

Brianna. Brianna, 33, is an educator who works as a district-level administrator in a large suburban, public school district. Prior to her current role she taught mathematics at the middle school level and served as a school testing coordinator. She holds a Bachelor of Science degree in Mathematics and a Master of Education degree with a focus on Curriculum & Instruction. She is a certified K-8 mathematics specialist and holds a 21st century skills certification. At the time of the interview she was pursuing a post-Masters certificate in Educational Administration and Leadership. She had this to say about the role of mathematics in her professional life-

> My career in mathematics has made me very employable…it's offered me several opportunities, prior to even receiving my degree, as far as tutoring and support to schools

> and teachers that were out on maternity leave. I feel like as an African American woman with a mathematics degree, far, few and in between, so that has paved the way for me in several aspects of my career.

Brianna grew up in a mid-Atlantic coastal state in a rural area with three public schools (one elementary, middle, and high). She had this to say about demographics of her middle and high schools-

> …[I]t was a very small, close-knit community, very few African American teachers. In middle school, I had two African American female teachers and one African American male teacher – one 6th grade, I had the male in 7th grade and my Algebra 1 teacher was actually a science teacher as well as a math teacher. In high school, I didn't have any African American mathematics teachers and I don't even recall having an African American male teacher while in high school… There were very few students from other backgrounds…it was probably about…60% Caucasian, 40% African American.

Students were placed on academic tracks at the middle and high school levels. Brianna's classes were on the advanced track and she described herself as, "a very good student academically." She was known as a student whom others could seek out for help. Outside of school she enjoyed playing softball, being outside, and spending time with her family.

Brianna took Algebra 1 in 8th grade. Her high school math course sequence included, Geometry, Algebra 2/Trigonometry, Math Analysis/Pre-calculus, and Advanced Placement (AP) Calculus, respectively. She stated that the classes she enjoyed the most were Algebra 1, Algebra 2/Trig, and Calculus. Additionally, she enjoyed science classes that were connected to math-

> I also loved physics and chemistry, which then I didn't have to take those classes but I did because they were so math heavy, they were such math heavy courses that I really thrived in those classes as well. So, I took chemistry and physics just based on the formulas and the heavy math content in those courses and I had a great teacher. I had the same teacher for both courses and she was awesome.

India. India, 40, works as an economist for a government organization. She has worked in her field for 17 years and currently serves as the Lead Trainer for her region of the organization. She has a Bachelor of Science degree in Political Science and a Master of Science degree in

Economics and Finance. Interestingly, she shared that she set her sights on a career as an economist from an early age, "I don't know, I feel like I've just always known about them since…like elementary school. My path did not change (laughs)."

India attended public middle and high schools in a rural, coastal area in the Southern United States. At the time, her school district had three middle schools and three high schools. She offered this description of the schools' demographics-

> It's a military town, so there's various cultures, but…I would say it probably was about 55% Caucasian and then maybe 30% to 35% African American and then the rest was some other, either Asian or Hispanic…So there was a mixture of students. I would say the schools represented that well. As far as the teachers, there was a nice mixture of teachers. And I had mostly honors classes and so even in that, there was still a good mixture of teachers racially.

India's middle and high schools placed students on academic tracks. Her classes were on the advanced track. From 8th – 11th grades, she took Algebra 1, Geometry, Algebra 2/Trigonometry, and Precalculus/Math Analysis, respectively. She did not take Calculus in high school because she graduated a year early. She indicated that the demographics of her advanced math classes mirrored the overall diversity of her school. One of her high school math teachers was an African American male who taught her for two years (different courses). India described herself as a high performing student and has fond memories of her mathematics and overall school experiences-

> I liked everything (laughs)…school was something I really enjoyed, so I probably liked most subjects. Math and science probably are where I excelled. I mean, I was mostly an A student, but those were like the things I really liked.

Keisha. Keisha, 41, is an assistant professor in the Clinical Laboratory Sciences department at a large urban research university in the mid-Atlantic. She has worked in her current role for three years. Prior to becoming an assistant professor, she worked for six years as a research scientist for a pharmaceutical contract research organization. Keisha holds a Bachelor of Science

in Clinical Laboratory Sciences and a Ph.D. in Microbiology and Immunology. She also holds a professional certification (Medical Technologist) with a prominent professional organization in her field.

Keisha attended middle and high school in a large, public suburban school district in the mid-Atlantic. Both the middle and high school she attended placed students on academic tracks. Her math course sequence from 8th to 12th grades was Pre-algebra, Algebra 1, Geometry, Algebra 2/Trigonometry, and Math Analysis/Precalculus, respectively. She recalled the representation in her math classes mirroring the demographics in her middle school while African American students were slightly underrepresented in her high school math classes. Keisha recalled having several African American science teachers, but did not have any African American math teachers in middle or high school. She enjoyed a variety of activities outside of school.

> I loved going to museums, science museums specifically, but any type of museum. Roller skating. I did, while I was in middle school, attend a couple like professional programs, even [at the university where I work], so I explored dentistry, I also went to a couple leadership summer programs that my mother put me in. Normal kid stuff. Video games, I did enjoy video games…yeah.

Natalie. At the time of her interview, Natalie (39) was working as a Supervisor of Informational Technology (IT) application support. She has been with the same company for 11 years with 7 of those years spent in IT and 4 in Supply Chain. She has worked as a project manager or in other supervisory roles her entire time with the company. Natalie holds a Bachelor of Science degree in Chemical Engineering with a minor in Business and a Master of Business Administration.

Natalie attended middle and high school in a large suburban, public school district in the mid-Atlantic. At both levels, the student body consisted of an even mix of African American and Caucasian students with a small percentage of students from other countries. While they were not

there at the same time, Natalie and Bryce attended and graduated from the same high school. I, the researcher, attended middle and high school with Natalie. We were (and remain) close friends and took many of the same classes together.

Natalie's middle and high schools placed students on academic tracks. Her classes were on the advanced track. "I do remember doing accelerated math in middle school, high school. Math was one of my favorite subjects. I appreciated the fact that it was either right or wrong, it wasn't a bunch of…in between, grey space like English." Natalie's mathematics course sequence from 8th to 12th grade included Algebra 1, Geometry, Algebra 2/Trigonometry, Math Analysis/Precalculus, and Calculus respectively. She also took math-heavy advanced science classes such as Chemistry and Physics. Natalie recalled being one of just three African American students in her advanced math courses. She had one African American male and on African American female math teacher between middle and high school. Outside of school she enjoyed dancing and activities at church such as Girl Scouts and singing in the choir. She summed up her extracurricular interests stating, "…just keeping myself busy with positive stuff".

Sable. Sable, 40, works as the director of a public health laboratory. She has worked in clinical sciences for 19 years, serving as director of the lab for the past three years. She holds a Bachelor of Science in Biology, a Master of Science in Medical Technology, and a Doctorate of Philosophy in Public Health (Epidemiology).

Sable attended middle and high school in a large suburban school district in a mid-Atlantic coastal state. She offered this description of the schools' demographics-

> Middle and high school actually were predominantly White. There was also an Asian presence in the high school. But otherwise, predominantly White…there was not as much of a Hispanic presence at either school before I left, so I think that's probably the majority of the makeup…if I had to estimate for high school, it was less than 10% [African American] and probably even less than that for middle school. I know my high school probably had…maybe just under 1,200…Graduating class had 300ish or so. Maybe a little

bit more. 300, 400. Yeah. So about 1,200 for the high school. I'm not quite sure on the middle school.

Students were placed on academic tracks at both the middle and high school levels. Sable's classes were on the advanced track. While she recalled the overall demographics of her middle and high school as being less than 10% African American, she indicated that the representation of African American students in her advanced classes was more than 10%. She had one African American male math teacher in middle or high school. Sable described herself as a "good student who worked really hard." She took Algebra 1 in 8th grade and her high school math course sequence included, Geometry, Algebra 2/Trigonometry, Math Analysis/Pre-calculus, and Calculus, respectively. Some of her favorite classes were marketing, her math classes ("They came easy"), and biology. Outside of school she participated in intramural sports and played the violin.

Male Participants

Bryce. Bryce, the youngest study participant, was 23 years old at the time of his interview. He holds a Bachelor of Science degree in Mathematics and teaches mathematics at the high school he attended. He is now colleagues with his high school Algebra 2 teacher, who he credits with inspiring him to continue pursuing mathematical knowledge. Bryce attended middle and high school in a large suburban, public school district in the mid-Atlantic. His middle school experience was atypical because he and several other students from his neighborhood school were bused to a middle school outside of his attendance zone. He will provide the backstory for this situation in his own words in the presentation of findings.

The population of Bryce's middle school was majority Caucasian. He returned to his zoned school for high school which was more diverse consisting of primarily African American and Latino students. His high school also included a small population of Caucasians and students from India and the Middle East. Both schools placed students on academic tracks. Bryce's classes were

on the advanced track. From 8th – 12th grades he took Algebra 1, Geometry, Algebra 2/Trigonometry, Math Analysis/Precalculus, and Calculus, respectively-

> I've always wanted to take physics. I never got a chance to, but I hear that that's very math heavy. I wish I would have taken it. I didn't. I started taking as much math as I could, because like I said, I was pretty decent. I was pretty strong in high school and in middle school so whatever the highest one was, I took in school…I went all the way to calculus in high school. I did the dual enrollment precalculus/trig class in high school as well.

African American students were underrepresented in his middle school math classes, but his high school math classes did reflect the overall school demographics. In high school, Bryce had on African American female math teacher. He offered this description of himself as a student in middle and high school-

> I wasn't quiet. But I did my work, and I had good study habits. I asked questions. I wasn't a troublemaker, and what else? I just – I kept to myself, but I did – you know, I did talk to people and had friends and stuff like that, but I really didn't…I knew I was there for school and that was it…I'm a musician so I did enjoy band class the most. After that was math…in school from middle up to college, math has always been challenging to me, but it is also fun because it is challenging.

Calvin. Calvin, 39, holds a Bachelor of Science degree in Chemical Engineering with a minor in business. He has worked with the same company for 17 years in a variety of leadership positions. Calvin is married to Ariel who was introduced above. They met in college while majoring in Chemical Engineering. At the time of their interviews, they were preparing to relocate to another city with Calvin transitioning into a new role as a Production Manager for Shipping, Receiving, and Finished Goods.

Calvin was born in Nigeria and immigrated to the United States in 8th grade. He completed one semester of middle school and all of high school in a suburban metropolis on the East Coast. He attended two different public high schools in nearby school districts for 9th and 10-12th grades, respectively. Both of his high schools placed students on academic tracks. Calvin indicated he took some honors and AP classes during high school but had difficulty remembering whether he was

on an advanced track for mathematics courses. He did recall taking precalculus during his senior year. His response to a different question, however, revealed an experience that typically applies to African American students on an advanced track-

> There were less African American students in those classes. I was always like you know, one of a couple – two, three, four. Most of my friends weren't in those classes…it was 90%, 95% White or Asian…just a handful, if any, Black students.

Calvin did not have any African American female or male math teachers while attending middle and high school in the State. He offered this description of himself as a high school student-

> …I made really good grades in high school, I was an A, B student. Mostly A's. However, I probably wasn't the most studious student (laughs). And I think part of the reason was,…going back to my previous experiences in Nigeria, you know, the educational system there…was much more rigid and much more structured…it wasn't age based per se. You could be younger and take certain exams and jump certain grades based on how well you did…When I came here, it was like "well, he has to be in middle school because he is this age"…I had to finish that semester in middle school and going into high school, I had already taken a lot of those similar classes…my study habits kind of lacked because I didn't have to study. I had already studied all this stuff previously and so I kind of skated through and as I got to stuff that I wasn't as familiar with, it was fairly easy to catch on. It was really just building on top of what you already knew. So it wasn't anything extremely hard and difficult until I got to college (laughs)…I loved math…I really enjoyed AP Government, like government class and history…I liked science, but I would say history, math and gym time were my favorite.

Damian. Damian, 39, works as a Senior Systems Engineer for a technology company. He has worked in IT for 19 years and holds several professional certifications in his field. He attended middle and the first two years of high school in a large suburban, public district in the mid-Atlantic. After his 10th grade year, his family moved to another large suburban, public district in the area. The demographics of the high school he attended for his junior and senior years was significantly different from the demographics of his former schools. Here, Damian describes the schools in his own words-

> …First I went to school, and I was in [District A], population…back then is probably…80/20…At least 70/30, 80/20 Black…10th grade, and then that's when we moved over to [District B], which is almost like a culture shock from – Because we went

> basically from 80/20 [White/Black] to like 2% White and everybody else Black, so it was definitely – and of course it didn't help I was a guy from [District A] that played the flute. That didn't really help out a whole lot either...Which, you know, that was cool. Everything was cool…I'm not going to say I lost interest, but the fire wasn't as great. If that makes any sense.

Damian's high school mathematics course sequence included Algebra 1, Geometry, and Algebra 2 respectively. He had this to say about academic tracking in the different schools he attended-

> Well, it depends…it was definitely different in [District A] than it was in [District B]. In [District B] it wasn't really necessarily a match…It was just basically, you know, you show up…if you made it then fine, you got in there, if you didn't, you didn't…It didn't really feel like more of an advanced class, if that makes any sense. It was just more so they kind of just threw you in…where they needed to actually fill a class or whatever the case may be. So…yeah, I guess you can say it was tracked on paper, but it didn't really match like the abilities and stuff of the student body. When I was in [District A] it was definitely, you know,…if you were in that class, you were supposed to be in that class. If you weren't, you probably weren't.

Damian had an African American female teacher for his 8th grade pre-algebra class in District A. He offered the following description of himself as a middle and high school student-

> I was never the athlete in class, so I hated gym…I definitely enjoyed…band, so I did the band thing…from an academic standpoint probably math was probably…one of my favorites, because I could use logic…Outside of school…I'm a huge car guy, so anything dealing with cars, car audio, car electronics, racing…I didn't really get into computers – like deep into computers probably until…pretty much after I graduated…I got a little bit into it in maybe my senior year, just because you needed at that point…to be able to, you know, type papers and stuff like that. And you know, after a while, it just makes more sense to…have a computer at home…and with it being at home, just basically…piqued my interest to start getting in there and get my hands on stuff, blowing stuff up and fixing stuff.

Thomas. Thomas, 38, is as a traffic engineer for a government transportation agency. He holds a Bachelor of Science degree in Electronic Engineering Technology and has worked in his occupation for 10 years. He attended middle school and some of high school in a public, suburban school district in the mid-Atlantic. For the other years of high school, he attended public rural high schools in the same state. He described the demographics of the schools as follows-

> …I was at two different high schools throughout. [One rural high school] was predominately…half Black, half White…it was just a country school…you could tell there was a lot of – the White people stuck to themselves, the Black people stuck to themselves, and that was it. There wasn't no [Latinos] or any others from that area. [The other rural] high school was predominately more Blacks than there was Whites. [The suburban] high school was half and half and everybody seemed like they got together, but they didn't. So it was either you were friends in middle school…[but] those friends didn't carry over to high school, the majority of them, everybody separated to their own selves in high school.

Students were placed on academic tracks at the middle and high school levels. He had this recollection of the tracking system at his middle school-

> Yes. (laughs) At [my] middle school they had High Flyers and Voyagers. So one of them, I forgot which one was which, I believe High Flyers was higher than the Voyagers. The Voyagers was the kids that wasn't as smart and High Flyers were the smart kids, so they separated them out, and then they still had – that's when they had separate Special Ed or LD we used to call it. They had those classes, which were separate. So you were on a different track from them. High school, I really don't remember in high school.

Thomas' mathematics sequence from 8th to 12th grades included Algebra 1, Geometry, Algebra 2/Trigonometry, and Math Analysis/Precalculus. Throughout high school he also took math-related classes such as Physics, Accounting, and Advanced Accounting. Among all of these classes, he was taught by African American male and femaless. Outside of school, he enjoyed working on cars, football, and track. When asked about experiences with mathematics outside of school he jokingly replied, "hustling, that's it."

Research Question 1:

What stories do successful African Americans tell related to their mathematics identities and engagement with mathematics?

Present Day Mathematics Identities

Participants generally shared positive stories related to their engagement with math presently and as they reflected on their adolescent years. Some spoke on how they continue to

enjoy math and apply it in their careers or personal lives. For example, Ariel, rated her current comfort level with mathematics as a "9,10" stating-

> I still do math. I mean, like regular math all the time. I haven't really gotten completely away from that. And you know, I use it in different ways now. So like right now, we're moving and we're doing the house thing, so I'm like looking at the finances and you know, looking at the mortgage rates and calculating things, so – and I've always enjoyed finances, so I can apply that in my personal life, the things that I love to do with math to kind of make sure that we're financially sound…and we're planning for the future. So I mean, it's fun."

Thomas shared the following information about how he uses mathematics regularly at work-

> I'm a traffic engineer…I'm an electrical engineer, got a degree from [local university]. You actually need a lot of math. You've got to stop at calc[ulus] III for my engineer role…doing a lot of formulas, some algebra, some trig, some calculus. It all depends on what you're working on. So I do calculations for voltage drop, wire size, [inaudible 2:28]…my job I'm doing now, I do pavement – calculate pavement depth and stuff like that.

Thomas rated his currently comfort level with mathematics as an 8 out of 10; however, he rated his comfort level with "new math" (i.e., the way his young son is learning math in school) as a 2. The remaining participants' current comfort level with math and rationale for the rating are summarized in Table 3. Several of them alluded to "new math" and their perceptions about it. This topic will be explored further during the discussion.

Table 3.

Remaining Participants' Comfort Level with Math

Name	Occupation	Current Rating (1-10, 1 = lowest)	Rationale
Brianna	Educator/District Administrator	9	" There's some new things that are coming down the pike…I would have to like revisit and do my homework on prior to being able …utilize it, but overall, math as a whole is a very comfortable space for me."
India	Economist	9	" I keep hearing about this new math and I don't know what it is, so (laughs)…I would have said 10 if I knew what new math was and…was able to grasp it (laughs)."
Keisha	Assistant Professor-Clinical Laboratory Sciences	6.5	"…I'm not as comfortable with concepts that I haven't used…[for example] Trig or geometry…I think because they weren't my favorite in the first place, when I see them now, I would get a little tense. Be able to work through it, but get a little tense about it."
Natalie	IT Project Manager	8	"They have this new math, you know (laughs)…And sometimes…just in trying to help [my son], it's like "wait a minute, what are they trying to do?"…I still am (laughs) very comfortable with math overall. Like I said, it's just trying to understand the new way that they do things."
Sable	Director of Public Health Laboratory	7	"I don't get to use my math skills as frequently anymore now that I'm in a management role, but I do frequently check the math of my work groups, so I would say about a 7."
Bryce	Secondary math teacher	7	"So before I graduated college…the modern geometry and the numerical analysis, classes like that, I feel like I didn't get a good grasp on it, because my teachers…didn't really go into why these things are the way they are …so I would like to learn a little bit more about those. But as far as like geometry, algebra, and calculus and stuff like that, I understand that. I can very much answer 10 for those, but as far as more…in-depth math, I'm not too sure."
Calvin	Production Manager	No number given	"…In my most recent job, I haven't necessarily used a whole lot of math. There are instances when…I have to do certain calculations…some of those things kind of come back to you…I think basic math is …used almost on a daily basis…I'm not over here at work…doing calculations related to calculus or differential equations or…statistics…There's folks I can rely on if I need to get into extreme detail."
Damian	IT Systems Engineer	6-8	"We homeschool our four kids…My wife, she hates math…So I'm the… 'math guy' here. So it kind of helps me to stay sharp on some of those concepts, and actually surprised me …when we started doing it… how easy it was for me to kind of remember this stuff and…teach them…some of these math concepts."

Mathematics Identities during Adolescence

Many of the participants stories about their self-perceptions are learners and doers of mathematics fell into one of three aspects of mathematics identity: ability to perform in mathematical contexts, beliefs about the importance of mathematical knowledge and the opportunities it provides, and motivation to obtain mathematical knowledge.

Ability to perform in mathematical contexts. Participants' stories demonstrated that experiences during the middle and high school years solidified their beliefs that they could learn and do mathematics. Damian recalled a "light bulb" moment in his 8th grade prealgebra class-

> I do remember when she started talking about…FOIL and PEMDAS and stuff like that…that point when it finally clicked…it was like a light bulb that kind of just came on, and I remember that feeling like, wow, I get it. I understand, I get it…I've never been excited about anything at school…But I finally was able to kind of relate, if you will, because it made sense…I could logically see, okay, this, that, and the other…I actually remember that like to this day, how I felt and you know, how kind of exciting it was.

Bryce shared a similar sentiment about his 8th grade Algebra 1 class, stating-

> When I took Math 7 it was kind of a blur, but then when I got to Algebra I it was just – everything was like boom…the way she just taught it, it was just so captivating, like the whole year, like she started us off with no calculators, making us do everything by hand so that we would understand what we're doing and why we're doing it, and then when we got to calculus, we didn't even want to use them…I felt I guess appreciative and I understood everything.

Several participants shared experiences involving recognition by others that affirmed their self-perception as a "math person". For example, Sable and Bryce described receiving public recognition for their abilities in mathematics.

> I remember being in my advanced – I think it was algebra maybe and I ended up getting the top score in the course for the year. So that was very affirming. And then outside of school, I was frequently tutoring others, family members, friends in their math courses and their science courses. (Sable)

Bryce also received a reward for being the top performer in his 7th grade math class. Additionally, he shared this high school experience-

> I think I was a junior, and my math teacher pulled me aside and he said…"we have these students that need help in their like Algebra I or Geometry, and your name was the first name to come up, because you're a great math student"…I helped that kid, you know, receive a better grade in class. That kind of like let me know that I was really decent in math, and that I could teach it to somebody, so that was a good experience. (Bryce)

Thomas, Ariel, Damian, and Briana also indicated that peers and family members looked to them for support with math, reinforcing their beliefs that they were "math people."

Beliefs about the importance of mathematical knowledge and the opportunities it provides. Several participants shared that their interest in mathematics developed earlier than middle and high school because of careers that drew their interest. For example, Keisha knew she wanted to be a scientist from a young age and recognized the connection between math and science in order to achieve that goal-

> I probably knew…by elementary school, no joke, that I wanted to be a scientist. But it morphed over time. At first, I wanted to be an astronaut, but then it morphed to then a physician and then I got to the fact that I liked lab work. So I didn't get to the lab work realization probably until freshman or sophomore year in college. But the whole time…elementary school on…science drove me on through…as far as my passion…I started to…have an understanding of how the two [math and science] were married and so I gained an appreciation of mathematics in middle school.

India mentioned an early interest in the math heavy occupation of economics-

> I: …You mentioned that you took some econ classes as part of undergrad…was it on your radar when you graduated from high school?
>
> P: Yes, it was already on my radar.
>
> I: How'd you learn about being an economist?
>
> P: Well, I don't know. I've always been kind of a nerd, so I don't know, I feel like I've just always known about them since like a young – like I was young, like elementary school. My path did not change (laughs).

Additionally, Damian discussed his early interest in working with computers.

> [It] probably goes back to elementary school when we first started…the whole computer programming thing, and just to see by doing a couple things that can make the computer

do certain things, and so I think I started a love for IT, and then just knowing that math was a big part of that, I knew that I had to – I had to excel in that.

Thomas also shared an early belief that math held the key to opportunity and prosperity, "Math was my best class. I treat[ed] math like money. You can do math, you have money. That's the way I felt. So I succeeded- I excelled in math."

Motivation and persistence to obtain mathematical knowledge. For the participants who discussed their early interest in STEM-related careers, keeping focused on that goal helped them maintain the motivation and persistence to continue gaining mathematical knowledge when faced with difficulty or challenges. Damian offered this self reflection –

> Once I set a goal for myself, I wanted to be – I wanted to make sure, number one, I was successful at it, and then number two, that I left absolutely nothing on the table. So I think for me it was just my personal motivation that I kind of developed, you know, using all those other aspects of, you know, expectations, and friends, and parents, and you know, all that stuff that I've taken to develop my own expectation, I felt like that I got to a certain point – because at some point you have to be accountable for yourself, right? So once I set that expectation, I felt like there was nothing that was going to stop me to meet or exceed, you know, that expectation. So I think for me it was probably more so revolved around the fact that, you know, this is my goal, this is what I want to do, and whatever obstacle that is put in front of me, I'm going to make that part of my goal to conquer it and to move past it so I can meet the end goal.

Other participants explained how the challenges encountered when learning mathematics were motivators in and of themselves. For example, Natalie and Bryce shared similar sentiments about enjoying a challenge-

> I think it was just the challenge in, you know, trying to figure things out and realizing, "okay, I get this, I understand this…let's see how far I can go" or…if the teacher was doing something on the board, "alright, let me see if I can figure it out before they get it all the way up there" type of thing. So constantly playing – making a game of it, making a challenge of it, and just enjoying trying to figure things out. That's something that I find fun, perhaps weird, but something that I enjoy. (Natalie)

> …I always said to myself if I'm going to spend all this time in school and stuff I wanted to be challenged, you know? So in school from middle up to college, math has always been challenging to me, but it is also fun because it is challenging…when I get frustrated with math, I appreciate the challenge, because it allows me to, you know, go for something, then

> I understand it. You know, that's a good reward in itself, yeah, if that makes sense. (Bryce, Individual interview)

> I think I always wanted to be different, and I always liked a challenge. I know good things don't come easy, so that's why I always like to strive to challenge myself more, and that's what kept me in math. The problem-solving aspect, it taught me to become resourceful, to be inquisitive, yeah, just not to quit, so – Because you will get the result if you can keep going, and I knew that. (Bryce, Focus group interview)

During her individual interview, Keisha shared a story of a setback with mathematics early in middle school that served as a motivator and ultimately turned into an affirming experience that reinforced her belief that she could learn and do mathematics.

> I remember actually my 6th grade year, the first semester of math I actually got an F and I think with that, the reason that I failed that first semester, six weeks or what have you at that time was I think I had a hard time transitioning from elementary school to middle school…But after that F, I actually didn't get any more bad grades in middle school at all…I'll go back to the example that I gave earlier…it was a positive and a negative. The fact that I got that F, and I had never gotten an F in anything…I was the kid that got the honor roll and you know, all of these awards…And then for that first nine weeks or six weeks…to get that F, that was an awakening that – and actually, that was a good lesson for life that my parents, they weren't that upset with me, but they were adamant that I turn that around. And I did turn it around. So that – the fact that I was able to take that F and…I'll call it going back to the real Keisha, working hard and figured out that everything is not going to come as easy to me as it did in elementary school, so to speak. Working through that and not letting it defeat me was the good – the good that I didn't stay at the F. I got back to the B. I don't think I got an A in that class. I think I got a B. So that was a good thing that I can think of as far as math.

Brianna shared two stories that had the potential to serve as deterrents but ultimately motivated her to pursue mathematical knowledge-

> My calculus teacher told my algebra teacher, who I was very close with, that she thought that I was cheating because I had the highest grade in calculus class. So that was something to me that made me want to go even harder and be even more successful in mathematics because she didn't…feel like I should be doing as well as…I was doing and that didn't have a negative impact on me. It actually had an even more positive impact on me. I think that was what did it for me.

> I hated geometry very much and I think it had a lot to do with the teacher, because she didn't understand enough of the content to be able to relay the information to us. And I do feel like she…could relate more with the White students than the African American

> students. That was actually my first F and I feel like if I wasn't…Black, I probably wouldn't have gotten an F on my progress report…in geometry in high school…as far as remediation, I guess because I was on the accelerated track, that wasn't a thing. That first F on my progress report and having to take that home caused me to…buckle down and figure it out regardless of how good she was. And I think probably because of my abilities in math, I kind of slacked in that class and wasn't doing what I was supposed to do, so the F made it real and I knew I had to buckle down.

Participants also discussed external motivators for persisting with mathematics such as meeting their parents' expectations. These external motivations will be further explored in a later section.

Research Question 2:

What interactions, experiences, and practices during adolescence contributed to the development of their mathematics identities?

Communities of Practice

Classroom. The mathematics classroom was participants' primary community of practice for engaging with mathematics. When asked about the classes they enjoyed the most during high school, all the participants listed mathematics among their favorites. All ten participants continued to enroll in mathematics courses through their senior year of high school—a move that is a choice not a requirement for high school graduation. As they reflected on their adolescent years, classroom memories seemed to be the haziest for participants; however, a few stories emerged about the atmosphere in their mathematics classrooms. Natalie recalled her 6th grade math class and spoke on how the teacher created a warm environment-

> I just remember that she was very kind. Her classroom was a very comfortable, great learning environment. She would let us play Oregon Trail and other stuff in the class, and you know, she had Kenny G music playing, she had us relaxed. It was just a very comfortable environment.

Ariel remembered working in a collaborative environment in her high school math classes-

> We worked in groups a lot. We were on a block schedule in high school, so that meant we took four classes per semester, 90-minute classes. So it was pretty long and so there was always time to do work during the class time. So if folks had questions or issues or needed help, yeah, I was very helpful with them.

Not all recollections of classroom environments were positive, however. Stories emerged from the participants related to representation (i.e., diversity or lack thereof) in their mathematics classes, particularly in advanced courses, and the impact on the classroom environment. Bryce described the reasoning behind his placement at an out-of-zone middle school and the chilly reception he and other students from his home school faced in their new environment-

> It was very interesting. I was in that year that I guess all the kids in elementary school scored so high on [a standardized test] they could either go to [their home school] or [another school in the district] and I was in that group…We were outcasted from the beginning, just because we were from [our home school], and then we were majority Black anyway. So it was very interesting…It was like we were the step-kids…we were supposed to be going to [our home school], and the teachers kind of didn't sit too well with us in the beginning. I think that was just based off of outside…accusations about the student population from [our home school]. But once the teachers got to know us, I didn't have too many issues.

When asked about the impact of their initial reception at the new school and whether it made him feel discouraged or motivated to prove everyone wrong, he replied-

> Yeah. I sensed a bit of both. Because it was just like "I know I can do this, and the reason why we're here is because of our [standardized test] scores, so you know we can produce a great test…or just great scores in general", so I was a little discouraged in the beginning, but like I said, as I got towards the end, and I built a relationship with the teachers, I think they realized that, you know, we're here to learn just like everybody else. We're here to…succeed just like everybody else. We're here to make a difference like everybody else.

During 7th grade, Bryce received public recognition for his mathematics achievement and felt a shift in the reception of his peers and teachers.

> We had an awards ceremony [in 7th grade]. I got the award from that, all the kids that were from that area, they knew my name afterwards…I don't think they despised me or anything like that, but after they realized…"I know just as much as you do and I can be proficient in this just as you can", they had a respect for me…I didn't feel like I was finally at their level until I got the award for math when I was there, and it was like, "okay, so he's really taking this seriously…he's not just here to make us look bad or anything like that."

Bryce summed up how the math classroom environments changed throughout his time at his middle school-

> … I felt as there was a teacher- like ostracized because…she would always like attack me. If I would like be excited to answer a question or something like that, so it kind of made me scale back…So this was in 6th grade. When I got to 8th grade, my other teacher, she was more open and excited that we were like, 'yeah, we know the answer', and stuff like that…

It is important to note that Bryce did not spend a lot of time during the interviews dwelling on the negative aspects of his middle school experience. I, the researcher, elected to unpack his experiences because they shed light on circumstances commonly encountered by successful African American students in environments where they are underrepresented.

Thomas initially had this to say about the representation of African American students in advanced mathematics courses in the schools he attended-

> Definitely there was an imbalance. I couldn't really tell you about the advanced classes. I was just in normal class and regular classes…But that was definitely – You knew what classes the smart kids was in…and what classes the kids that wasn't so smart was in…it was imbalanced. It was more white in the advanced classes…than it was the African-American kids.

After further reflection, while responding to a later question, Thomas realized that he was on an advanced mathematics track-

> None of my closest friends was in any of my classes (laughs) with me. My math classes – I probably was in the high math class, and they was like on a lower level math, but yeah, I had none of my friends in my math class…it didn't bother me, but if you look at it now, like no one else got a fair – they didn't get a fair shot. It's like you got – once you were labeled I guess in elementary and middle school, that stuck with you throughout, which is bad because people can change and, you know, you can change and go a different way or a different route, but you still can't make up for it, because once you're labeled, you're labeled.

Among the participants, Thomas had the unique experience of having almost all African American mathematics teachers through middle and high school. The one exception was a Caucasian

mathematics teacher in high school. He sensed low expectations for his performance in her classroom which negatively impacted his motivation and led to him being transferred to another teacher early in the school year-

> …She didn't care at all, that's how I felt...I only had her for probably about a month or so, but after that I got transferred to another teacher…Come in looking a certain way or something like that, she didn't like how you was. And I mean, I could say I probably was disruptive in class, but you was already labeled to her when she saw you or whatever for some reason…I didn't pay any attention in her class. She couldn't tell me anything, help me out in any way, and it just wasn't – it wasn't a positive feel from her, and I let her know it.

Sable was the only study participant who attended a school where the advanced mathematics classes had more African American students represented than were represented in the school's overall population. "I think that we definitely had more African Americans in my advanced classes than the other classes – than I would have expected I guess I should say. It was probably more than 10% in the advanced coursework." However, her closest friends were not in her mathematics classes. "Not often…I was in advanced classes and my peer group wasn't…my closest friends were the people in the neighborhood and some of the people in the neighborhood were in the advanced classes, but not the majority of them." When asked if she ever felt 'othered' in her classes or felt a need to prove she deserved to be there, she shared-

> Yeah, all the time…my elementary school was in inner-city Richmond and…in 5th grade I moved…into a predominantly White school, which was probably less than 5% Black and I had to prove something every day there, because I came from inner-city Richmond. They had already made an assumption about my abilities. So when I got to 6th grade, some of that carried over. I can remember frequently my dad going to the school to, I guess, fight on my behalf…It was mostly adults in middle school. In high school, it was a mixture of both. Probably more so students than adults. You know, things were like oh, you've just got…into that because you're Black…especially in 12th grade. They're like "oh, you got into that school because of affirmative action". Those types of comments were made.

Calvin's experience with representation in advanced math courses was similar to others who found themselves to be one of few minority students in the classroom. When asked if the lack

of representation in his class made him feel "othered", he offered the following reflection based on his experience as African American who was also an immigrant-

> I didn't really feel so much of an 'other' because of the classes. I guess you could say I felt that way just being here…I dressed differently, I spoke differently. I had a thicker accent. My clothes were different…So whether it was to the White folks or to the Black folks, they all saw me as different. But as you start to make friends and you figure out a way to kind of get over the somewhat bullying or…jokes and stuff…I used humor for that…they start to understand you, they see past that. And so I mean, in those classes, I was fine. I didn't necessarily see myself as…'oh I'm just the token student'…I kind of felt that throughout my experience, even with my Black friends, because I knew I was different. And my name was different…as soon as you hear my name, people joke about that, whether it was the teachers, the students. Some were doing it just because…it was different and they were genuinely trying to learn, but there were some who (laughs)…were just being cruel and trying to make a joke at my expense. So I mean, I always kind of felt I was like the 'other', regardless of what situation I was in, whether I was with my Black friends or not. But ultimately, you know, the folks I hung out with the most were my Black friends and they were more accepting

Brianna's experience in advanced mathematics course was also one of underrepresentation; however, she did not feel it had a negative impact on the classroom environment-

> [I was] often one of the few Black students. As I can recall, there were three African American females and one African American male and we were in the same classes all the way up from middle school all the way through high school.

While most of her closest friends were not in her advanced mathematics classes—she was and continues to be friends with two of the African American students who were in advanced classes with her—she never felt 'othered' in the mathematics or as if she had to prove she belonged there-

> I think I was just naturally good at math…I wasn't very social, so (laughs) there wasn't a lot of interaction there. I had friends but I was kind of in my own world and I just basically found something that I loved to do, which was math, and I became very good at it through my own internalizing and working. Like I said, I didn't like working with other people. It was more so I did it on my own.

Keisha's experience with representation in advanced mathematics classes was similar to Brianna's-

> So in middle school, the kids that I hung out with were not actually in any of my classes. So I usually hung out with my neighbors and my close friend, and she still is a close friend, at that time, she was in classes that were I guess at a different learning pace than my class.

> So my class was a little faster learning pace and so I was always friendly with the people who were in my class, but after school, I hung out with my neighborhood friends. So the answer to your question is no, not really.

When asked if she every felt othered in those classes, she responded-

> No, not in middle school. Nor in high school. So in high school, my friends that I mainly hung out with, we were in the same classes. Like so we were in the same – in the same level of class. So that worked out because we all were in the band as well. But no, I didn't feel othered. No, not at all actually. But I'm trying to think. It seems like at one point in my life – I want to say I didn't start feeling othered until later on, like in college, I started to feel a little bit of othered. But not in middle school or high school… I always felt respected as far as my capabilities, even going back to elementary school. I never felt as though they said – no. I'm thankful for that, now that you point that out. (laughs)

Outside of the mathematics classroom. Several of the participants recalled engaging with mathematics outside of the classroom. These communities of practice included after school programs, school-affiliated educational programs, summer programs aimed at exposing adolescents to careers in math and science, and free time activities at home or with friends that incorporated mathematics or other STEM-related skills. While many years had passed since those experiences, some left a lasting impression on the participants.

After-school/School-affiliated programs. Ariel, India, Damian, and Bryce recalled three different experiences with after-school or school-affiliated programs. For instance, Ariel participated in an after-school program, led by her geometry teacher, aimed at exposing students to engineering, "I was a part of [a program whose name was an acronym] and I don't even remember what it stands for, but I know it's something about engineering". India discussed competing in a Battle of the Brains type activity called the Academic Challenge-

> Outside of school, like I was on – we had this thing called Academic Challenge…it starts in elementary school. So in elementary school, middle school, high school, I – not every year, but throughout my time, I was usually on an Academic Challenge team and I was on it for different subjects at different times. So it wasn't like I was always on a math team or always on a science team. I was on different teams, you know, just depending.

Damian and Bryce both described experiences with a community math and science center that sent STEM educators to local schools for enrichment lessons and activities and also offered opportunities for classes to take fields trips to the center for onsite activities-

> Those visits to the math and science center back – you know, back in those school trip days, that was, you know, again, on that which you can do and all how science and how all that's related to math, you know, it just makes you even that more excited – that much more excited about trying to do, you know, excel in math and science, is because this is the type of things that are interesting. (Damian)

> The main thing I can remember is the math and science center. Being able to solve a problem. Like they give you popsicle sticks, and you can make a, like put rubber bands around it and make like a harmonica type thing with it. That's pretty – That was pretty intriguing to me growing up. (Bryce)

Summer programs. Ariel, Keisha, Natalie, and Sable spoke about opportunities to participate in summer programs that exposed them to mathematics outside of the classroom and gave them a chance to experience life on a college campus. The programs in which Ariel, Natalie, and Sable took part were aimed at exposing underrepresented students to college and STEM. When sharing her summer experiences, Sable also made mention of the math and science center previously discussed by Damian and Bryce.

> So I think I went to a summer math and science camp at some university pretty much every summer I think after my freshman year. So I think I went to the University of South Carolina and then I went to – where did I go next? I think I went to Morehouse. That's where I got my love of Spelman. So the girls stayed on the Spelman campus, the guys stayed on Morehouse campus. I think I went there – did I go there two years in a row? I think I did. I think I went two years in a row and then the last year I went to – I went to FAMU, I went down to Florida. (Ariel)

> Other mathematics outside of the classroom? Oh, so in the leadership class – and this is kind of mathematics slash I guess – I don't know if it was like economics – a leadership course that I had took that summer, I'll never forget this. We had to come up with a business idea and we had to like figure out…how much profit we were going to make for our business. So that summer, I did – my mom likes to make crafts, so she helped me make – what did we make? We made either like these little decorative pots and I sold them basically to her friends…but I learned in there like the cost of materials versus profit and how you have to increase the price over the material price in order to make a profit. So in that leadership class, I got kind of real world mathematics there. (Keisha)

> I was selected to participate in the Young Scholars program that was at [a local university] for the summer and it was focused on math and science. There were kids from different schools across the county, city. We had teachers from different places, even folks from corporations around that were represented…we had classes, they went through and taught us stuff…it was cool…it was for African American kids and…to have that experience on a college campus, we were working on advanced level math stuff for us…it was very much math focused…we talked about statistics. They gave us a project that we had to work on and…present the results of our project. So it was the type of thing where you could see math in real life, if you will, where we were actually out and about and using it. There were lots of kids that were part of the program, and the teachers that we had in the program made it a lot of fun. That's one thing that always stuck out to me, that I still remember as a fun math thing that I really enjoyed. (Natalie)

> I did a program…called [X] and it was [X] Area Programming for Minorities in Engineering…I did that and…a few things at a [local] Math and Science Center as well, but it was more science based, not as much math. I think I did one math kind of type activity there that I can recall. But yeah, so those are probably the only two that I can think of right now…[X] was summer and it was held at [a local] University. Math and science [center] was during the school year. (Sable)

Free time activities. Several of the participants also shared stories of how they engaged with mathematics during unstructured free time. For Keisha, Damian, and Ariel these activities were clearly self-selected and self-motivated. Keisha offered several activities in which she engaged during her free time-

> …in elementary school, for me it was kind of self-driven…We had an Atari at the time, and so I would go to the school library in elementary school, get the programming books to see what I could get the Atari to do and show me on the screen. So that was fun…at the time, making the Atari be a calculator, and making colors come up on the screen, and I would sit there as long as I had to, to figure out this program and put it in. Later on, everything was more science driven. My mom actually works at the DMV here downtown and the science museum is right next door. So summer times, that's where I was, at the science museum, and I would stay there for hours, upon hours, upon hours, or like mentioned before, the math and science center, go there and just everything related to science I've loved since I was a little girl.

Damian shared a story of how his friends applied mathematics outside of school when working on car stereos-

> …a lot of my friends, you know, guys are generally math, science types…we were all pretty much, from a subject standpoint,…more into math than anything else, and then as I

> got older when…dealing with like car electronics…That's another one of those kind of moments, too about kind of relating back to your previous question. When you start dealing with like automotive electronics, especially like car stereos and stuff like that, when you start building customized boxes, and you've got to…deal with like volume, and you've got to deal with like area, and surface area…When you start wiring stuff, you've got to deal…how to calculate the ohms, so you won't you burn your amps up and stuff like that. And…I did a lot of that with a lot of my friends…We would kind of spark discussions while we were doing this whole car stereo thing…for example, one of my friends, we were building like the speaker boxes for his pickup. So we had to make sure that the subwoofer actually needed…I think it was like a foot and a half, 1.5 cubic feet for it to have that optimized sound or whatever, but being that he had a pickup truck, you were very limited on size…because of the speaker box itself and where you could place it. Long story short, we had to go through all this stuff and do different measurements with each box, so it could still meet that optimized cabin space, but still we had to build each box separately, because there were other obstacles that we had to overcome being that it was dealing with a small space…We kind of used math to…open up big discussions and do stuff like, 'alright, so we need to wire it like this, so we can get the most power out of the amp and do this'…

Ariel described having fun in her free time while working on additional math assignments beyond her schoolwork in. Calvin, her husband, also described working on mathematics during his free time although it was not as clear whether he completed the assignments of his own volition or if it was an expectation set by his parents.

> I think from a youngster, math had always been fun and interesting and you know, my mom would bring home these workbooks so that I could kind of get ahead and because I always wanted to do all these math worksheets and stuff like that. So she would bring those and I would work on them in addition to whatever homework and stuff and during the summer and it was always just fun, so. I think that was really why I ended up in more of a math science field. (Ariel)

> I remember as a child, in Nigeria, they would have over the summers, we had these books. And it wasn't just math, but math was like a key one, where we had to work on those. Every day, we had assignments that we had to do. So we were not just sitting home and you know, playing all day every day. I mean, we played a lot, but we also had a couple of hours every day where we were working on assignments, you know, whether it was mathematics and English, you know, some of those other classes, but math was always a crucial one that we worked on almost every day in…what we call summer here. Every day we were off during the holidays. (Calvin)

Socializing Agents

Parents & Family. Parents and family were, by far, the most influential socializing agents discussed by participants. Many of the participants recalled the support and encouragement received and direct and indirect messages shared by one or both parents or from other family members. Three of the participants, Keisha, Natalie, and India all had a parent with a degree/professional background in mathematics. Below is a collection of participant stories about the role of their parents and family played in their mathematics socialization-

> Definitely. Yeah, my parents. I mean, they knew the importance of mathematics and that it could take you really far. You know, they saw that I had a passion for it. Like I said, they would give me extracurricular workbooks and things early on to kind of feed that curiosity and help me to get ahead. And I enjoyed that. I actually asked to go to summer school when I was like going into the 2nd grade. They let me go (laughs). And so I actually was doing like 3rd grade work, during summer school. (Ariel)

> So I come from a family with a lot of teachers (laughs), and so you know, it was always education is important. I have a cousin who was a math – math and science teacher, and so she was very focused on that and you know, as I got older, she was, you know, "hey, want to come and judge this science event" or that sort of thing. So I mean, just from having the teachers around, I understood the importance of learning and you know, making sure that you try hard. My mom, before she had my sister, used to teach math and so I had a math helper at home (laughs), which was good. I think when there was something that perhaps I didn't understand, I could go to her and she could help me figure it out. I don't remember her specifically saying math is important, but I think the support that she provided, and the fact that it was something that was of interest to her, spoke of its importance. (Natalie)

> I had a very supportive family. Actually my father majored in mathematics at [a local university] and taught mathematics for a while in [a local school district]. So he was not happy to see that F [in 6th grade], but we worked through that…it was basically preached at home through my father, the importance of math…Mom has always…wanted me to do my best at things…as far as helping me to study…the day in and day out, preparing for tests, reviewing materials, flash cards…through middle and high school…Mom helped me with that…Dad…he was really a stickler for math, going back to elementary school…speaking of things you don't forget. He would always say your 3s look like 5s, you need to make your 3s not look like 5s…moving on in middle school…and high school – where he's teaching me his way of math and I'm going "Dad, I can't go back to school and show this concept…or do the formula this way, then they're going to say I'm doing it wrong." He would argue, like "this is the right way, this is the way you do it. You see, you get the same answers…I want my daughter to do it this way". And (laughs) so…that

part was a little more difficult…honestly, what I would do is I would appease him and do it his way in front of him…I would go back after he's taught me and go back and figure out how to do it the teacher's way after he's gone through it and do it that way…[Dad] always would ask about my grades in general…if I got a 97 on a test – this is even in college…he would always say well, what happened to the three points? And versus mom would say, you know, well, congratulations, I'm so proud of you. But dad always pushed me…not in a mean way, but he would say like…you lost three points, so why didn't you get those three points?...I was motivated and pushed in different ways by my parents…So I would turn usually first to Dad [for help]. If for some reason, either he didn't have time or if I was having a girl moment and didn't want to talk to Dad at the moment, I would go to either one of my friends. I did have a close male friend in high school that was very good at math. So sometimes I would go to him, or I would go to the teacher. But usually if I went to the teacher, it wasn't for extensive help. It would be to review something real quick after class that I didn't understand, so the question would maybe take the teacher 10 minutes or less to answer. But for long sessions where I might not have understood full concepts, then I would go to usually Dad to ask. (Keisha)

Always my parents…with most classes, but especially with math, you know, and my dad in particular because he – you know, he was an engineer and you know, he always preached the importance of understanding mathematics and how it could help you in a lot of ways, in terms of the way that you think, but just in terms of application as well, depending on what you end up doing. (Calvin)

And I guess for me, I think I would echo what a lot of people already said. Definitely at home. I had parents that were pretty much "you're going to go school, and you're going to do well". Of course you don't want to upset that, because you know, that kind of messes up things at home. Happy home, you know, so you've got to keep that. So I think that was probably one of the bigger influences for me was my parents. (Damian)

My older brother…was always looked at as the math wiz…that brotherly competitive spirit, you always want to be like your big brother or better than your big brother, so that was what drove me to take a higher interest in math…he made me jealous, because my family would always get him to do math problems, and he could do it all in his head, and I wanted to…do the same thing. So that was one instance. One of my older cousins, he didn't go into mathematics, but he was very proficient in it, and I aspired to follow in his footsteps as well. (Bryce)

My dad…pushed math, you know, he was always like if you can do math and you can do science, you can do anything. My mom was always great at math. She didn't push it quite as hard, but she was always…the person I could go to if I needed help with things. But it was pushed extremely hard by my father. (Sable)

Sable's closed her interview with further reflection her parents' contribution to her success in mathematics. Her statement captures what many of the participants felt about their parents' support and expectations-

> I have to give that to my parents, I think. My parents pushed the sciences, again, and they pushed my mathematics and there was no acceptance in my household of underperformance, really in anything but definitely not in math and science. And so they made sure that I didn't fear it, you know, math wasn't something to fear. That I was able to manage it and do it successfully. And so that became very empowering after a point. So I think that's really the answer. It was my family.

Teachers. In addition to their parents, participants credited their mathematics teachers, and a few other staff members, with igniting or sustaining their interest in mathematics and/or for providing support when they encountered challenges. The teacher impact described by the participants primarily fell into two categories—messages and expectations related to the importance of mathematical knowledge and teaching style or instructional support.

Messaging & Expectations. Brianna had this to say about messages she received at school about the importance of mathematics and the expectations held be a particularly impactful teacher-

> I learned that math was everywhere…I can remember my 6th grade math teacher making math relevant, which I think was very beneficial. I really don't remember how I felt about math prior to middle school. But my 6th grade teacher…had been in the game for a long time and she made math real and relevant and relatable. 7th grade was a good experience. And then 8th grade was probably the best experience that I had in a math classroom and that was my algebra teacher who is now my daughter's godmother…she just held me accountable…because I was good at math, I had the potential to slack on the little things and she made sure that I didn't slack. I would do everything start to finish. I kind of had the attitude, "why do I have to do this" (laughs). Typical honors kid. And she made sure that she constantly reminded me why I had to do it and held me accountable, which is what I needed…I think my middle school career gave me the greatest foundation…middle school math and algebra gave me the foundation that I needed.

During both his individual interview and the focus group discussion, Damian spoke of his "mean" 8th grade pre-algebra teacher who he now holds in high esteem-

> …she was probably the meanest teacher I ever had, but she had the most impact on me. She was my pre-algebra teacher, and by far she probably had the biggest impact on me

> from a math standpoint, or probably from any standpoint…I do remember when she started talking about…like FOIL and PEMDAS and stuff like that. I kind of remember at that point when it finally clicked…it was like a light bulb that kind of just came on, and I remember that feeling like, wow, I get it. I understand, I get it…I've never been excited about anything at school. Just basically show up and just get the grades and leave. But I finally was able to kind of relate, if you will, because it made sense…I could logically see, okay, this, that, and the other…I actually remember…how I felt and you know, how kind of exciting it was. (Individual interview)

> She was one of four African-American teachers that I had through my entire K-12 school experience…When you walked in her class, you're going to respect [her]. And if you wasn't, you was going to have some problems…back then I equated that to…be super mean, but now as an adult, she wasn't really mean, but she was just about her business…You weren't going to come in her class and play around…You're going to learn this math…that made me – number one, I'm going to focus, because I don't want any problems… (Focus group discussion)

Thomas also spoke about several African American teachers who shared messages about the importance of mathematical knowledge that stuck with him-

> But the funny part about it, it's all African-American teachers that had it, that effect. Mr. Joseph, who was in middle – he was in high school. He was an African-American teacher. Ms. Rogers, she was an African-American. Those are the ones that had a positive impact or would help you with math, and showed you the importance of math…my math teacher, Mr. Washington, he said you need math so you can keep track, and actually my accounting teacher too…She always stressed the importance of "if you don't know math, you don't know your money, you don't know how much money you're making or money you will have. People can steal from you, and it shows you that you still have that amount of money, which you – and you don't. So you need math so you can do – know how much money you're going to have to be successful in life." That always stuck with me.

Calvin recalled his teachers discussing the value of mathematical knowledge and his school counselor's suggestion that he consider engineering as career given his achievement in mathematics-

> I did have teachers who in high school were advocates for mathematics and just also explaining how it could be useful in the future. Guidance counselor. I do remember my guidance counselor but you know, she was more so talking about – and I guess it was in terms of going to college and figuring out what I wanted to do and you know, being that I had such good grades, especially in mathematics, one of the suggestions was engineering.

For Keisha, the influence of a female African American science teacher carried over to other classes such as mathematics-

> At school it was one of my science teachers that I actually looked up to and I wanted to be like her, and so I didn't want to disappoint her either, so I did well in my classes for her and for my dad.

Teaching Style & Support. While classroom memories proved to be the haziest for participants, several of them remembered specific teachers' teaching style or their willingness to support students. In addition to her demeanor and expectations, Damian described his pre-Algebra teacher's delivery of the content-

> …Secondly, just her delivery, once you actually got past the fact that…she was like mean, her delivery was really…pinpoint accurate. So it was very easy to kind of understand, and there wasn't a whole lot of fluff on either end, because she…was relatively serious…This is the concept. This is how you do the concept. And this is how you arrive from point A to point B. So for me, that was good to me, because again it helped me with my logic, and I can actually logically kind of put the steps together, and it logically makes sense to me. (Focus group discussion)

While his pre-algebra teacher left the greatest impression, Damian stated that, overall, he felt he could turn to any of his middle and high school teachers—particularly in District A where he attended school through 10th grade—for support if he had challenges with mathematics-

> I think I was kind of fortunate in that I didn't really have any dream killers, if you will. And maybe I was just too naive to kind of recognize those dream killers, because…I was dealing with my own like personal stuff with like family and stuff like that, so I think I probably use a lot of those as like more so as motivators than like dream killers. So I can't really pinpoint anybody that I may have saw was like, "oh yeah, he's trying to steal my joy" type deal that I can really you know, think of, and if anything I've had a few teachers that actually…encouraged me, because they saw something in me that I didn't see.

Calvin spoke earlier of the messages he received from his father, an engineer with a Ph.D., about the importance of mathematical knowledge. However, when asked about who he could turn to for support with mathematics, he shared why that support primarily came from his teachers.

Ultimately, he both credited his father and teachers with contributing to his persistence and success with mathematics-

> My teachers. School. You know, I mean, would have turned to my dad but you know, at that point early on…he was in Nigeria while we were here, you know, that whole lottery system thing…only… so many people…you know, win the lottery, if you will, in that time period. And so it was years before he was able to come here to the States. But typically, if I had issues with math, I would stay behind and talk to a teacher and work through some extra problems and stuff of that nature…Well, [success] with math, I mean, I would just say encouragement. You know, my father was big into math, you know, I had the support that I needed from my teachers. If I needed help, certain concepts, you know, even through college, understanding that when you need help, you ask for it. You know, I think that was big in keeping me going and just from a mathematical standpoint, I understood a lot of the concepts and I was able to build on that, so it wasn't too hard to keep going.

Bryce recalled the impact of one middle and one of his high school mathematics teachers and how they helped change his perceptions of who could learn and do mathematics-

> I think it was the teachers, I think like my algebra I teacher and my algebra II teacher. I think it was those two teachers that allowed me to see my potential in math, because the way they taught it… They both made it very interesting…it was like, I get this, and you know, it changed my disposition on math… They made me feel that I could do math, especially as a minority. It's frowned upon amongst us, so they made it fun and interesting…I was like "I can help you do math, I can help you do math", and I realized that I liked the challenge.

India shared a story about a male African American mathematics teacher, who taught her for two years in high school, describing his individualized attention and availability to his students-

> I have a story…a lot of times when you're in math or in science, you have to show your work, and I've never been good at it. I guess math is something that I've always just – like I can see the answer without having to work it out, which I guess is a blessing and a curse. But…one of my teachers who was my teacher for two years when I was in high school, he would help me so that I could break out the steps and I really appreciated that he would take the time to do that because it's like okay, I know the answer but I can't tell you how I got it… And he at first was [penalizing me] but he knew I wasn't cheating and so he…was willing to take the time to work with me on that… it was myself and I think there were about four other students that were also African Americans, whenever we wanted to, he would assist us. And so if that meant…we wanted to stop by during his lunch, if we had the same lunch or one of his planning periods or after school or before school, he was always accessible for us to assist us…he definitely was a great guy and always helpful.

At the close of her interview, in addition to crediting her mom with preventing math from becoming a gatekeeper, India reflected on the supportive teachers she encountered along the way-

> Well, I will say starting with like my mom, who was also an educator—but at the elementary school level—and great teachers throughout the process, you know, that helps. I mean, I'm sure if you have a teacher that isn't supportive or isn't willing to assist you, then if you do have an issue, you're not going to be successful…if no one's making [math] so that you're enjoying it or you know, something that you look forward to, then you're probably not going to put any effort into it. So I think I was fortunate that I did have some pretty good teachers in that aspect. (India)

Peers. The third and final group of influencers discussed by participants was their close friends and/or classmates. Some peers served as a source of support for some participants, creating a feeling of "we're in this together," while others served as role models to emulate. For example, Bryce reflected on how he and other students from his home school leaned on each other while adjusting to their new middle school-

> It was like a veil, like these are the [kids from our home school], these are the [kids from the new school]. It felt like that when you walked in the door how the teachers would talk to you in the beginning…So we stuck together…we all rode the same bus pretty much, and we stuck together and helped each other out… We were all in the honors classes. We didn't play games. We was like, 'no'.

While discussing her sources for mathematics support, Natalie reflected on the impact of our friendship on her motivation to pursue mathematical knowledge-

> My mom was very much into math. She used to teach math at one point, so had her as a math advocate, and I would say within school, friends. The most important one being you, Teri, just having, I'd say, an accountability person, someone that was very like-minded, you know, get together, okay, we're going to do this, we're going to knock this out type of thing. So I think a combination of those things kind of helped get me going and continue to go.

Keisha shared how her friends served as a source of positive peer pressure to continue challenging herself and pursuing her goals-

> In high school especially, the young ladies that I hung out with, we all had aspirations of going to college. So I think in a good way, in retrospect, it was good peer pressure that I was involved with, as far as I thought to myself well, if she's taking this math class or

> taking this science class or taking this class in general next year, well, I need to be taking that too. Or you know, she's taking that and she's planning to go to UVA or you know, whatever, or if she's taking the SAT and she's preparing for the SATs, I need to be doing. So it's almost like peer pressure in a good way. And these – to clarify, these friends that I had in high school were all African American young ladies that we kind of pushed each other in a good direction.

Calvin and Damian spoke on how their friends viewed them as a source of support or someone to look up to-

> Being that I was in a lot of those AP classes, [my friends] kind of looked at me as the smart one and "oh, he's the smart one. Oh, he's going to go to Princeton...he's making straight As", even though it was A's and B's. You know, they were trying to elevate me to…that certain status. (Calvin)

> …Like back then, we didn't have…the power of the internet like we have now…if you had difficulty, you either…went to a friend or a lot of times even in school I was probably one – somehow I was the guy they were coming to, which that makes no sense to me…(laughs)…but we would kind of rely on each other then. There were teachers that were available to assist…the after school type deals or you know, after class, hey, I've got a quick question type deal. But most of the time we just kind of relied on each other. (Damian, individual interview)

> …So I think that was probably one of the bigger influences for me was my parents. And then in school I would say probably a combination of friends and my pre-algebra teacher in middle school. My pre-algebra teacher was really, really tough…and her expectations were extremely high, especially for, you know, younger African-Americans. And from a friend standpoint, I would say it was more so I – they kind of looked to me as a guide as to what to do or how to do certain things. Not that I was the smartest guy in the room, but you know, they always looked at me as one of the smart guys. I didn't want to really let anybody down, so that's kind of from a friend standpoint. (Damian, focus group interview)

Research Question 3:

How did the construction of participants' mathematics identities align with or contradict the construction of their other identities? How did they negotiate any contradictions?

Responding this question proved to be the most difficult for several participants. Sharing my personal experience helped to clarify the intent behind the question but it also made some of them realize, in retrospect, that they had not given it much thought when they were young. To

illustrate these instances, some of the data is presented as a verbatim excerpt from the interview transcript while other data is presented in a summary quotation as in the previous sections. The variation in experiences made it difficult to identify collective themes; therefore, findings are presented by participant in this section rather than thematically.

Thomas

> I: How did other aspects of your identity such as race, gender, or peer group intersect with your developing mathematics identity?
>
> P: (sighs) I really couldn't answer that. I don't even know how to answer it (sighs)
>
> I: Well, kind of what I'm trying to get to, I've – from personal experience and then from hearing stories of others, there are some folks I feel like you almost have to choose are you going to fit in, are you going to be smart?
>
> P: Oh yeah, that's always the case. That's always the case. Are you going to dumb yourself down for your friends or are you going to be smart and do your work and just – Me, I really didn't care. I just knew I had to get my work done or get beat when I get home.
>
> I: So you were able to tune out those influences?
>
> P: Yeah. Correct. So it really wasn't an influence of 'hey let me be cool', because I had a mom that made sure you did what you had to do or you're going to pay for it. So instead of getting in trouble, you get your school work done, no matter what. So when it came down to it, that I had to – you know, wanted to be the cool one, hang out and laugh, yeah that happened for like one time, and that was like a one time thing, and after that you better be on track for yourself.

India

> I: How did other aspects of your identity, such as race, gender, your peer group, how did those aspects of your identity intersect with your developing mathematics identity when you were in school?
>
> P: I'm not sure that it did, I mean, because – I think probably because it was so diverse, it probably didn't really – I think if we were talking about like elementary school, there were probably not a lot of minorities in my elementary school, but like in middle school and high school, there were enough of us that you never felt like an outsider.

Keisha

I: Okay. How did other aspects of your identity, for example, race, gender or possibly peer group, how did those other aspects intersect with your developing math identity when you were a teenager?

P: This is interesting. So I don't think I really thought about it in that way until I was older and people who understood – and actually, I'm just learning that term, intersectionality, if I got that right. But that I think it was always just kind of part of me and it didn't – wasn't pointed out to me until probably I was in my 30s, that quote unquote I was unique, but I'm – I'm hoping that I'm not as unique as people have said, in the sense that my friends when I was in high school, we all were kind of like me, my close friends, in the sense that we all did well in school, but we all liked to quote unquote have fun outside of school as far as we played video games, we hung out at the mall. We did those things, but doing well in school was also part of our identity. So as far as in high school, I wasn't as affected by it until I got, like I said, in my 30s and people started to say well, you're – you know, you're Keisha with the PhD and how did you – but you're Keisha that goes out and hangs out with your friends and maybe has some wine and so forth and so on. We don't understand this. So how can you be both people? And I had to explain to them that I'm one person, a person that loves science (laughs), a person that loves math. I like math, I would say. Again, I love science a little bit more. That respects math, let me say that. And that yeah, I have been successful, but I'm a whole person and I like other things besides just science and math. So the whole liking math and achieving in math and science when I was in high school, again, it didn't really affect me as far as my friends. It was not until later in life where it was – or my family. My family didn't point it out to me either. It was not until later in life when I met other people that pointed that out to me.

Natalie

I: How did other aspects of your identity, such as race, gender or peer group intersect with your developing mathematics identity?

P: (pauses) I think it – I don't know specifically math, but just – so I think about getting to middle school, right, and you know, we're in these classes and it's just the three of us, right? You, me, Renee, right?

I: (laughs) Yeah.

P: And how we get treated by others that look like us was not great at all (laughs).

I: Yeah.

P: Especially in middle school. I remember, you know, having conversations with the guidance counselor about it, I remember from – I know you know who I'm talking about, being called "grey". You know, the things like that that you kind of deal with because you're (laughs) playing in both spaces. And when I say both spaces, I mean with those

> that look like us and with those that don't, because we have the accelerated math, science skills and knowledge. I think it helps make you more well-rounded but at the same time, it's difficult to manage. I think it has helped me in the corporate world, because again, I still go to places and I'm the only one or you know, one of few, to the point where I don't really pay too much attention to it anymore. It may take me a little bit before I realize it, just because it has been (laughs) the norm for so long. Of course always happy to see those that look like me, but just keep chugging along and doing what I can in the absence of. Does that answer your question?

Ariel shared how her mathematics identity aligned with her overall student identity during adolescence, stating-

> I feel like consistently from very early on, probably like 4th grade through high school, my identity was…being the smart person in the class and so it wasn't like a question. And my peer group, the folks that I ultimately – middle school, high school, were friends with, were kind of in that same circle. I probably should have taken more time to spend (laughs) with other people outside of that peer group. But I don't…think I felt like I needed to hide that about myself because it was very well known, so it was just a thing, another thing. So really I don't think I had that challenge and being in a very small school, I mean, it would have been hard to hide it (laughs), to be honest.

Sable, however, felt a bit of a conflict about being viewed as a "smart kid"-

> So I would say that, you know, I was always the smart kid and that wasn't necessarily the most popular thing, so people were – so people were tough on me. Sometimes my peers were pretty tough on me like as far as teasing and things. And so I won't say that I made an attempt to underperform in those courses, because I had to answer to a higher power named Dad but (laughs) I definitely didn't try to stand out as a star in the courses. I didn't answer questions, I didn't volunteer to be on committees or you know, to be in math bowls or things like that, because I didn't want to add to the teasing and things like that. But I think that's about it.

During the focus group discussion, Damian and Natalie reflected on the challenge of navigating their mathematics and overall student identity with other aspects of their identity such as race or gender-

> So as a young African-American male, you didn't – How can I say this? I didn't want to be considered like the nerd of the group, if you will. So you still wanted to kind of be cool. You still wanted to be, you know, part of the in crowd. So I think that may have played a part in me at one point not being as good as I possibly should have, because I wasn't really focused as I should have been. But then it goes back to that accountability piece that we spoke of earlier, and so you have to balance, you know, wanting to be that, you know, guy or that person that's still relatively cool, but yet you don't want to kind of mess up…what

you're supposed to be doing rather. So I think that really had an effect on me for a while, until I actually had to make a decision, do I want to be just that one guy that's super cool and the in crowd, or do I want to go and meet or exceed my expectations. So I mean, that was kind of a hard decision I had to make at a very young age, and you know, obviously I chose to kind of go the other way. (Damian)

I always wanted to be the class clown. I always wanted to be funny, because you know, it goes back to one of the previous questions, that struggle between wanting to be, you know, with the in-crowd and still be relatively cool, but yet still handle my responsibilities, and [my pre-algebra teacher] wasn't having any of that. And I think it was at that point, around that time, that I kind of made that decision and like, "okay, well, it's about time for me to go ahead and just say forget what everybody else thinks and just go do what I have to do." And you know, I still ended up being, you know, relatively cool or whatever. (Damian)

Middle school and high school was a bit interesting. I feel like at times there were battles on both sides. The comments that you made before, I would get the, "oh, you think you're special or you think you're better than us" type of thing from the Black kids, and then from the White kids, I guess because they were the ones – We were all in honors classes together, and they were very familiar with us, they would say – (laughs) I remember the one particular comment, "oh, well, you're not Black, you're gray". Just because I guess (laughs) they felt so comfortable. They weren't threatened. They felt like we were somewhere in the middle. So kind of getting those types of comments from both sides made it difficult. But again, you know, kind of going back to the having friends to go through it with you made things better, because we understood each other. You know, we understood the comments. We had similar goals, and like I said, just kind of helped push each other to, you know, keep going and be our best regardless of what other people were saying. (Natalie)

Keisha and Damian shared how being in a peer group with similar interests helped

reconcile different aspects of their identities reconciled potential contradictions-

I was fortunate to have a group of young ladies, all – they were African-American – that we all kind of were considered the smart girls, but we were the smart cool girls, so we were respected for being smart but not ostracized for being smart. But me personally, I had that set of friends. It was four of us. But I also had another set of friends that were I guess kind of the cooler kids kind of, but they respected me for my goals, even though they may have had different goals, their parents may not have had them to the same – or held them to the same standards that my parents held me to, but they were okay with that. So I was lucky to be able to kind of shift between two different groups to kind of grow my, what I felt at the time, my African-American identity, but still having a goal driven to be a professional later on in life. So I was able to kind of balance the two, between the two groups. (Keisha, focus group discussion)

Well, it really depends on like – So like with everything right? It really depends on kind of your social group that you kind of hang out with. If you socialize with a lot of like math

heavy type guys, then it's kind of like a relatable thing between your peer group, versus if you have people that's more into like literature and stuff like that…Depending on the type of person you are, it would kind of push you towards other aspects. But me, a lot of my friends, you know, guys are generally math, science types…so a lot of my friends…we were all pretty much from a subject standpoint, we were more into math than anything else, and then as I got older when – you know, dealing with like car electronics…I did a lot of that with a lot of my friends, a lot of my homeboys, if you will. So I mean, we would spark discussions…We kind of used math to like kind of, you know, kind of open up big discussions and do stuff…(Damian, individual interview)

Research Question 4:

What foundational mathematics concepts and skills do participants highlight as useful for being prepared to pursue the training necessary for their careers?

Foundational Concepts & Skills

Table 4

Participants' Foundational Mathematical Knowledge

Participant	Occupation	Foundational Mathematical Knowledge
Ariel	Engineer: Director	"Regular" math, higher level math, chemistry
Brianna	Education Specialist	Middle school math, including Algebra 1
India	Economist	Algebra, trigonometry, pre-calculus, geometry, statistics
Keisha	Researcher/Assistant Professor-Clinical Laboratory Sciences	"Basic" math classes, Algebra, statistics
Natalie	IT Project Manager	Algebra, "basic" math, proportional reasoning, number sense
Sable	Lab director	Algebra, trigonometry, precalculus
Bryce	Secondary mathematics teacher	Algebra 1 and 2, Geometry, Trigonometry, Problem solving skills
Calvin	Production Manager	"Basic" math, statistics, computer science, Algebra 1, Algebra 2, Pre-Calculus
Damian	Systems Engineer	Algebra, geometry, formulas, finding a particular variable, Proportional reasoning, statistics, reading comprehension
Thomas	Traffic Engineer	Algebra, "Basic math", Calculus, College-based level general math in high school

Table 4 summarizes participant responses when asked about the mathematical knowledge that provided a solid foundation and prepared them for success with mathematics as they pursued their careers. Generally, participants felt that Algebra 1 was the foundational mathematical course all high school students should be required to complete. Bryce, Damian, and Natalie shared additional thoughts on foundation mathematical knowledge during the focus group interview-

> Problem-solving skills. That's a big one. Or being able to read something or see something and make a problem out of it, or solving equations. As a teacher, I see that's a big issue or big misconception amongst all students. They just – They want just the answer. They don't care about the process. They just want the answer. So I think problem-solving skills is really important. The highest math, if I can put it into you know, one big scope, the highest math I think every student should take – and they could take other math if they want to, is algebra I, because that's the – if you're missing something, call it X, and then make a problem to figure it out. (Bryce)

> I concur. I think number sense is – I think you have to have that too to have the foundation in place to be able to even figure out the numbers that need to go in any equation or understand the numbers that need to be a part of the proportion or, you know, whatever. But I think, you know, the number sense is a good foundation that you need to have as well. (Natalie)

> Can I add something real quick? I definitely agree with all – I definitely agree with that. But one thing that really no one talks about, and I'm just speaking from – my wife and I, we also home school, so we look at a lot of different curriculums and stuff like that, and one thing I see that is kind of helpful – I know it helps with our kids, is reading comprehension as a whole. Because if you can't – especially when you go into, you know, word problems and taking word problems, and trying to convert those into equations and stuff like that, if you can't really decipher what you're reading, then it makes it that much more difficult to be able to even apply a lot of these concepts. (Damian)

The Figured World of Mathematics

An unanticipated finding in the data was participants' articulation of their perceptions of the figured world of mathematics. While the term *figured world* is likely unfamiliar to them, the thoughts that they shared while reflecting on their experiences and adolescent self-perceptions

gave insight into how they viewed the figured world of mathematics and their place within that world-

> I never saw it as a gatekeeper. I never saw it as something that was a roadblock. I always saw it as something that I enjoyed and even when there were challenges, it's just like okay, it's just another challenge. Let me see what it is that I need to do differently in order to solve it. So I think…what we could do with our African American folks is…not to treat it as it's this big crazy beast that is so difficult and so hard. You take it one step at a time…you take each problem on the surface as what it is and you work through it. I think early, early, early on, you try to make it fun. It was always fun for me. And so I think that's one of the things that I try to tell our kids is, you know, hey, just in regular conversation, try to make games out of math and make it fun. The more you can do that, the more it just kind of becomes second nature and it's not like this big stigma of oh, it's so hard. (Ariel)

> The fact that there's like a right or wrong answer where you can like check yourself and know that you got it as opposed to it being more of a nebulous, subjective kind of thing, like writing a paper or something like that, I just – I like to know if I got it or not. And math was very much that for me. I could do it and then flip to the back of the book and yes, I got it right or not quite, let me go back and look at it again. (Natalie)

> I think from a math perspective, when you're learning new things, whether it's math or – math is – it's analytical, right, you're learning something analytical, you're shaping new synapses and you know, connections in the brain and you never lose that. I mean, it teaches you to think a certain way and you know, whether you ultimately decide to use that in the future, even, you know, you go into business or whatever it is, you're going to use basic math to some degree. But you know, the analytical skills that it gives you I think will help – help you go far. (Calvin)

> I like education. I like to help people and making a difference. And my whole main goal for teaching is to change the disposition of math among minorities. That's why I went back to [my alma mater], because I know it's a minority heavy school…and my goal is to, you know, the few students that I do happen to, you know, be in front of, I want them to understand that math is not hard, it's just you know, you've got to understand. You have to study, got to ask questions. You've got to use your actual brain to, you know, get better at it and practice. It's not as easy as just memorizing facts. It's taking the knowledge that you have and then applying it, you know, to solve a problem. Math is – And I tell them I say all the time, I say math is not numbers, it's problem-solving. We just use numbers to explain the concepts. (Bryce)

> Math…was probably more so one of my favorites, because I could use logic. I could logically kind of put things together versus like your histories and grammars and stuff like that. It was more so memorization, and like applying rules and stuff like that. Of course you had to apply rules in math, but it was still logical for me, whereas you know, like history and English and stuff like that was just, you know, you basically memorize the rule and you read, and more memorization. (Damian)

Summary

This chapter opened with an introduction of each study participant in order to provide background and context for their stories about their adolescent experiences engaging with mathematics as well as insight about their current understandings of these experiences. Participant introductions were followed by a presentation of the findings organized by research question and themes that emerged during the analysis. In Chapter 5, I will elaborate on these themes and their broader implications.

Chapter 5 DISCUSSION, RECOMMENDATIONS, & CONCLUSION

Overview

This study used narrative inquiry to examine the mathematics identities of African Americans working successfully in STEM-related occupations, asking them to reflect on experiences and interactions during adolescence that contributed to their self-perceptions as learners and doers of mathematics. Four research questions were used in this inquiry: 1) *What stories do successful African Americans tell related to their mathematics identities and engagement with mathematics?* 2) *What interactions, experiences, and practices during adolescence contributed to the development of their mathematics identities?* 3) *How did the construction of participants' mathematics identities align with or contradict the construction of their other identities? How did they negotiate any contradictions?* 4) *What foundational mathematics concepts and skills do participants highlight as useful for being prepared to pursue the training necessary for their careers?*

Ten African Americans were recruited from the following careers—engineering (electrical and chemical), product manufacturing, information technology (IT), economics, research in the health sciences, and education. Participants' stories provided insight into their current and adolescent mathematics identities, the communities of practice in which their mathematics identities developed, and the socializing agents who contributed to their developing identities. Participants who experienced tension between their mathematics identity and other aspects of their identity such as race or peer group shared how they navigated those contradictions. Lastly, participants shared their perspectives on the mathematical knowledge that provided a strong foundation and prepared them for their future.

This chapter begins with a discussion of the revision of the conceptual framework followed by the themes introduced in the presentation of findings and their broader implications. The discussion is followed by recommendations for practice and ideas for future study. Next, is a discussion of the study limitations and changes I would consider when replicating this research in the future. The chapter concludes with final words on the project and its contribution. It is important to acknowledge before launching into implications and recommendations that a qualitative study with this small of a sample is not generalizable to the larger population. That said, the findings still offer a contribution to the literature and may provide insights that are transferable to individuals demographically similar to the participants.

Discussion

Evolution of the Conceptual Framework

As mentioned above, the themes that emerged during data analysis were introduced in the presentation of the findings. These themes became evident as the provisional coding scheme (see Appendix G) grew during coding and was then condensed into the final code list (Table 2, Chapter 3). After revisiting the original conceptual framework multiple times while finalizing the coding scheme, I decided it was inadequate to reflect what I was seeing in the data. While the original conceptual framework (Figure 1, Chapter 2) integrated Wenger's (1998) communities of practice, Holland and colleagues' (1998) figured worlds, and Sfard & Prusak's (2005) collection of reifying stories with Martin's (2000) definition of mathematics identity, it failed to reflect *how* experiences within communities of practice and interactions with socializing agents contribute to learners' mathematics identities. It also failed to elaborate on why mathematics could be viewed as a figured world.

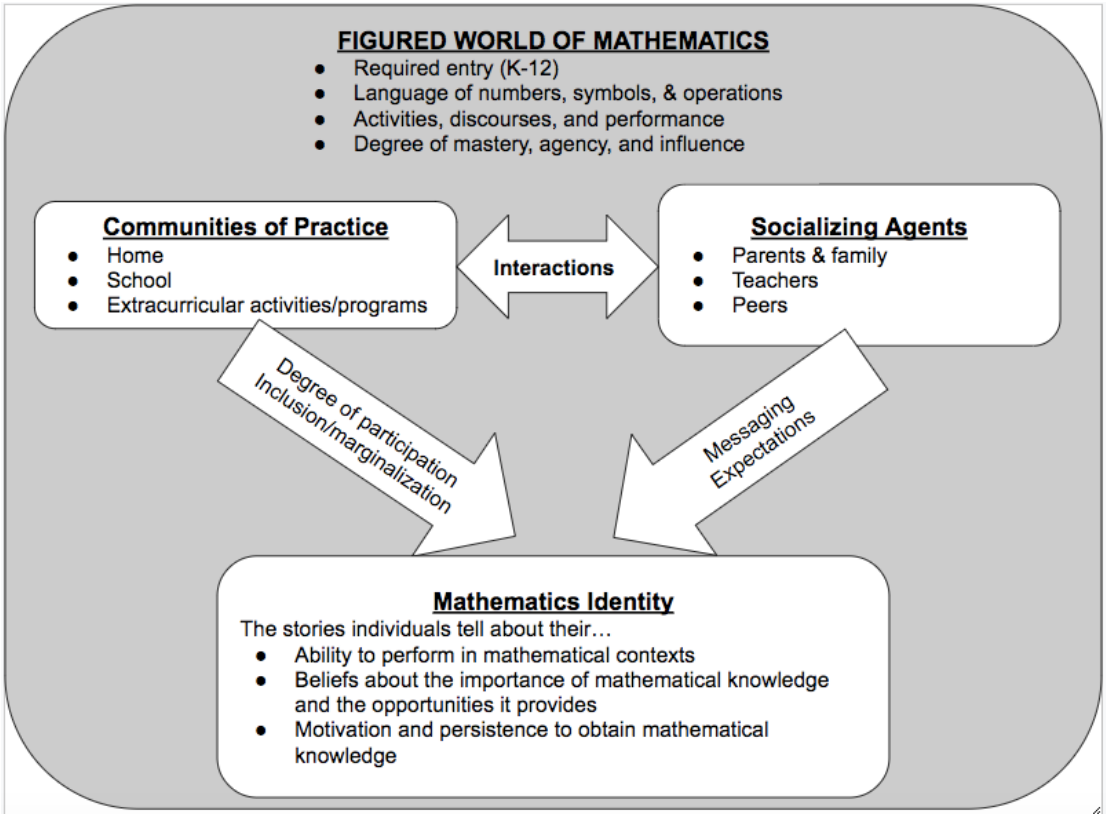

Figure 2. Revised/Final Conceptual Framework

The revised framework (see Figure 2) also integrates Wenger (1998), Holland et al. (1998), and Sfard & Prusak (2005). Additionally, mathematics identity along with the places and people who contribute to its development continue to be situated within the figured world of mathematics. The first notable difference in the new framework is that it identifies characteristics of mathematics that demonstrate how it exemplifies Holland and colleagues' (1998) description of figured worlds. Another change to the framework was the adaptation of Martin's (2000) definition of mathematics identity from four components to three. Perceptions of opportunities and constraints in mathematical contexts and beliefs about the importance of mathematical knowledge (Martin, 2000) were condensed into a single category, beliefs about the importance of mathematical knowledge and the opportunities it provides, because many of the participants' reflections did not fit squarely into either of the original categories. Gee's (2000) aspects of identity—specifically

nature, discursive, and affinity identities—were found within the data; however, they were not salient enough across participants' experiences to warrant inclusion in the conceptual framework. The next revision to the framework was the separation of communities of practice and socializing agents to reflect that they are two distinct influences on mathematics identity. However, these two influences are not entirely independent of one another. Much of individuals' mathematics socialization takes places during interactions with socializing agents within communities of practice. This relationship is reflected in a bidirectional arrow. Finally, arrows were added to illustrate the aspects of communities of practice (degree of participation, inclusion/marginalization) and socializing agents (messaging, expectations) that contribute to the stories individuals construct about their mathematics identities. The final version of the conceptual framework more accurately represents the collective themes that will be unpacked in the following sections.

Mathematics Identity Among Successful African Americans

Mathematics Identity Then

Participants' adolescent mathematics identities were shaped by internal and external influences. For example, Damian and Bryce's adolescent perceptions of their ability to perform in mathematical contexts were positively impacted by moments in their math classes where the information "clicked" and they realized they had a solid understanding of the material. These realizations about how the skills they were learning fit into the "big picture" are examples of what Nasir and Hand (2008) referred to as "accessing the domain" of mathematics, a factor necessary for supporting the development of a practice-linked identity. Six of the participants shared stories of external recognition (e.g., receiving class awards, being the person others turned to for help with

math) that to bolstered their perceptions that they were "math people". Their experiences are examples of the other two aspects of developing a practice-linked identity—integral roles and opportunities to make a unique contribution and feel valued (Nasir & Hand, 2008). Additionally, the aforementioned experiences of being viewed by others as a "math person" offer an example Gee's (2000) discursive identities and demonstrate how recognition from other individuals can positively influence a learner's beliefs about their abilities to learn and do mathematics.

A combination of internal and external factors also contributed to participants' adolescent beliefs about the importance of mathematical knowledge and the opportunities it provides and their motivation and persistence to obtain it. Early career interest emerged an influential internal factor for Keisha, India, and Damian who all shared that their interest in STEM-related careers developed in elementary school and gave them an appreciation for the mathematical knowledge they were learning. This finding adds support to studies that demonstrated that between the ages of eight and fourteen is a critical time for the development of interest in math and science-related careers (Sneider, 2011) and that middle school math and science interest are positively associated with STEM interest in high school and college (Dabney et al., 2012). While Thomas did not mention being set on a specific career, his stories revealed how his interest in mathematics was sustained by the belief that it would open doors to prosperity. Focusing on how mathematics would help them achieve their long-term goals helped these participants to stay the course when facing challenges. Other examples of internal motivators were finding enjoyment in the challenges of learning mathematics (e.g., Natalie and Bryce) or facing setbacks such as poor grades that they were determined to overcome (e.g., Keisha and Brianna). The external influence of other individuals contributing to participants' adolescent beliefs about the importance of mathematical knowledge will be unpacked during the discussion of the role of socializing agents.

Mathematics Identity Now

Grootenboer and Zevenbergen (2008) argue that the identities students develop in mathematics classrooms endure and impact their future engagement with mathematics. Findings from this study offer support for their argument. Perhaps the most unmistakable evidence of participants still possessing positive mathematics identities is their work in STEM-related occupations. With the exception of Bryce, all the participants had been in a STEM occupation for a decade or longer. Additionally, stories they shared about their current feelings and engagement with mathematics demonstrated that the positive identities developed in adolescence have lasted into adulthood. Natalie, Thomas, and Damian discussed how they provide support to their children at home. Thomas and Ariel spoke on how they engage regularly with math in their professional and personal lives, respectively. While Calvin and Sable indicated they did not engage with mathematics on a regular basis in their current roles, they knew they had the skill set and resources to apply mathematical knowledge when needed. Keisha and Brianna felt there were certain topics they would need to study or revisit to refamiliarize themselves with that mathematical knowledge, but they expressed comfort with math overall. Regardless of their current level of engagement, participants still viewed mathematics as a comfortable space they had the skills and knowledge to navigate.

These findings corroborate Martin's (2006, 2007) research which presented African American adults who held on to their adolescent mathematics identities well into adulthood. Unfortunately, the adults in Martin's studies held negative perceptions of themselves as learners and doers of mathematics and ended up avoiding math engagement for years. These individuals eventually returned to school in their late twenties or thirties to challenge and transform their beliefs about their ability to gain mathematical knowledge. For every one of those adults who re-

engaged, however, there are many more African Americans who disengage from mathematics in middle or high school and never look back. To increase the representation of African Americans in STEM-related occupations and transform the perception that African Americans are not "math people," African American learners need a foundation of positive experiences and supports during middle and high school. It is during those years that individuals began to recognize and internalize what they are capable of learning and doing. The messages and beliefs they internalize have a long-term impact on the options they perceive as available to them, and thus the goals they pursue.

The Role of Communities of Practice in Developing Positive Mathematics Identities

Wenger (1998) described communities of practice as social communities in which individuals share a common set of beliefs and/or practices. During adolescence, participants were able to engage with mathematics within several different communities of practice. While the classroom was their primary community of practice for engagement with mathematics, many of the participants described opportunities where they applied mathematical knowledge in after-school (or school-affilitated) programs, summer programs, and during their unstructured free time.

Degree of Participation

Wenger (1998) argued that individuals' identities are constructed in relation to the degree of participation or non-participation in a community of practice. In this study, degree of participation in a community of practice—specifically inclusion or marginalization—did emerge as a factor influencing participants' adolescent mathematics identities. Experiences with inclusion or marginalization in the math classrooms varied among the participants. For example, Natalie and Ariel spoke of math classes that were inclusive, collaborative environments. Bryce, Thomas, and Sable, on the other hand, faced the challenge of marginalization. Bryce described how he and the

other students from his home school were initially made to feel unwelcome and unworthy to be in their new environment. Thomas recalled encountering a Caucasian teacher who treated him like he did not belong in her advanced class. Sable offered examples of how she felt 'othered' in her advanced classes and had to prove she deserved be there.

For the participants who experienced marginalization, it was not enough to extinguish their beliefs in their abilities to learn and do mathematics, perhaps because they had a foundation of other experiences serving as protective factors for their developing mathematics identities. Another possible explanation is that, because the experiences only took place in one or two of their math classes over the seven years of middle and high school, the other years of being in inclusive classroom environments gave them perspective to see these classroom environments were "out of the norm". Recognizing that these environments were atypical could have offered a level resiliency to their developing identities. However, this is not to say that negative experiences made no impact. Bryce, for example, spoke on how his initial experiences in his new school caused him to feel both discouraged and motivated to prove that he could perform at the level of his classmates at the same time. Thomas also described how picking up on the feelings of his Caucasian teacher negatively impacted his motivation while in her class. Ultimately, the individuals who experienced marginalization exercised agency over their circumstances (e.g., Thomas transferring to a different math teacher, Bryce & Sable continuing to do their best work and achieving success and, eventually, public recognition in their math classes) and bolstered their mathematics identities in spite of the challenges.

In communities of practice outside of the classroom, participants' stories suggested full inclusion. Marginalization did not appear to be an issue, perhaps because these were environments the participants were invited or self-selected into. The importance of mathematical knowledge

appeared to be a common belief around which the practices of the structured programs/communities (e.g., Academic Challenge (India), community math and science center (Bryce and Damian), STEM focused summer programs (Ariel, Keisha, Natalie, and Sable)) were developed. The participants who engaged with math during their free time appeared to do so out of an interest related directly or indirectly to mathematics. Keisha's free-time activities (programming her Atari, visiting a science museum) and Damian's work on car stereos with his friends were indirect interests that often led to practices that required the application of mathematical knowledge. Damian's story about building speaker boxes, installing car stereos, and the math discussions sparked between him and his friends during those activities offered an example of Gee's (2000) affinity identities and how individuals with similar interests can come together and co-create aspects of their identities. This phenomenon was reflected in his own words as Damian characterized his peer group as "math guys". Ariel and Calvin had a direct interest in expanding their mathematical knowledge and used some of their unstructured free time to strengthen their math skills using practices that mirrored the practices of the math classroom. These activities reinforced their beliefs that they could learn and do mathematics. Borum and Walker (2011) reported similar findings among African American women who held doctorates in mathematics. Their participants also shared many examples of engagement with mathematics outside of school through after school programs, summer programs, or other informal activities and discussed how those experiences bolstered their beliefs about the importance of mathematical knowledge and their ability to learn and do mathematics.

Representation

The findings point to a possibility that the degree of participation within a community of practice is related to group members' representation within the community (i.e., individuals in the

minority might be less likely to experience marginalization if they are present in greater numbers). Racial representation appeared to be salient in some of the participants' advanced mathematics courses. For example, Bryce and Thomas' experiences with marginalization occurred in classes where African Americans were underrepresented. By Sable's recollection, African American students' representation reflected, or were even a bit higher than their representation in the overall school population, but I would argue that ten percent is a still a small percentage of a school or classroom's demographic and qualifies as underrepresentation. However, marginalization was not the experience of every participant who found themself in a classroom community where they were underrepresented. Natalie, Brianna, Keisha, and Calvin did not recall feeling discouraged from full participation. A search for literature related to underrepresentation and classroom environment in advanced mathematics courses yielded few studies, the most recent of which was conducted in 2010 using a data set from 2002 (Riegle-Crumb & Grodsky, 2010). Riegle-Crumb & Grodsky (2010) and other studies they cited focused on why certain racial groups were underrepresented or on academic outcomes for underrepresented students. I was unable to locate studies that explored the classroom environment perceived by underrepresented students. While the representation of African American students in advanced math classes has improved over the years (Riegle-Crumb & Grodsky, 2010), I believe there is still a need to examine their experiences within those classrooms—particularly considering the current racial climate of this country—and the impact on their mathematics identities and desire to continue engaging with mathematics.

The Role of Socializing Agents in Developing Positive Mathematics Identities

Socializing agents are individuals or structures that communicate explicit or implicit messages to young people and contribute to their self-perceptions or perceptions of the world

(Young et al., 2017). The findings showed parents/family members, teachers/school staff, and peers to be socializing agents who played an important role in the development of participants' adolescent mathematics identities. Four themes emerged to describe socializing agents' influence on mathematic identity—support, messaging, expectations, and role models.

Support

Various forms of support from social agents emerged out of the participants' stories. Many of them recalled who they turned to for help with math homework or for reteaching concepts and clarifying misunderstandings. Sable, Natalie, and Keisha spoke about seeking help from their parents and/or friends who were also strong math students. Calvin, India, and Damian mentioned staying after class, after school, or visiting a teacher during a free period such as lunch to receive additional assistance when needed. Damian and Bryce alluded to how they and peers in their math classes turned to each other for support. Sable shared that her father frequently went to school to advocate on her behalf when she dealt with negative experiences. Ariel and Calvin talked about materials their parents supplied for extra practice at home. Ariel, Sable, Keisha, and Natalie's parents also provided support for engagement with mathematics outside of school by allowing, encouraging, and facilitating their participation in out-of-school math/STEM-related programs.

Messaging

In addition to support, participants recalled the messages they received about the importance of mathematical knowledge. Some of those messages were indirect (e.g., Natalie shared that her mother's enjoyment of the subject, and willingness to help when she didn't understand spoke to its importance); however, several of the participants received explicit messages about the importance of mathematics. Calvin, Keisha, and Sable recalled their parents,

particularly their fathers, preaching the importance of mathematics. The messaging they received can be summed up with Sable's recollection, "If you can do math, you can do anything". Thomas and Brianna recalled teachers demonstrating and providing real-life examples of how math was "everywhere". In addition to his parents, Calvin recalled his school counselor recommending he consider pursuing engineering because of his strong performance in math and science. Bryce recalled receiving a direct message from his Algebra 2 teacher about his teachers' belief that he was a strong math student when he was recommended to serve as a tutor for other students. Receiving this message from his teacher is an example of Sfard & Prusak's (2005) *second-person* identity (i.e., an identifying story told to an identified individual). The experience of receiving that message and subsequently helping another student achieve success helped Bryce incorporate that story into his *first-person* identity (i.e., the story he told about himself) (Sfard & Prusak, 2005). Some of the direct messages received from parents and other family members were more general (e.g., do well in school); however, Thomas, India, Damian, and Natalie acknowledged that those messages impacted the effort applied in their math classes in addition to other classes.

Expectations

Imbedded within messages about the importance of mathematical knowledge were expectations for participants' performance in their math classes. Authority figures (parents and teachers) were the socializing agents whose messages also communicated high expectations for learning mathematics and academic performance in general. Keisha, Sable, Natalie, Calvin, Damian, and Thomas all mentioned how their parents' expectations contributed to their motivation and persistence. Keisha and Damian also talked about teachers they held in high esteem. Keisha mentioned science teachers she did not want to disappoint while Damian spoke about his pre-

algebra teacher's high expectations for her students and how he did not want to "bring trouble" on himself by failing to work up to the level of her expectations.

Role Models

Several of the participants alluded to individuals they viewed as role models and wanted to emulate or make proud. Others recognized that others looked to them as role models and they felt a responsibility take that role seriously. For example, Bryce talked about looking up to his older brother and a cousin who were considered "math whizzes" in the family and how that inspired him to learn math so he could be like them. Keisha referred to African American science teachers she looked up to and whose opinion she valued. She also talked about a group of her friends who shared similar aspirations and how they provided positive peer pressure to one another to enroll in certain classes or take other actions to move closer to achieving their goals. Damian and Calvin shared how their friends came to them for help or looked to them as the "smart" one. Knowing how his friends looked to him gave Damian a sense of responsibility toward them along with the authority figures in his life as he did not want to disappoint his peers either.

Synthesis – Socializing Agents

Prior research has demonstrated that supportive experiences and interactions bolster students' motivation and persistence to gain mathematical knowledge. Many of the same themes found in previous studies, which explored factors supporting mathematics success and positive mathematics identity construction among African American learners, emerged from my participants' stories about their mathematical socialization. These themes included support, expectations, and experiences received from parents (Berry; 2005, 2008; Berry et al. 2011; Borum & Walker, 2011; Ellington & Frederick, 2010; Martin, 2000; McGee & Pearman, 2014),

interactions with role models (Berry et al. 2011; Borum & Walker, 2011; McGee & Pearman, 2014; Stinson, 2008); positive interactions with teachers (Berry et al. 2011; Borum & Walker, 2011; Ellington & Frederick, 2010; Martin, 2000; Stinson, 2008), and interactions with like-minded peers in school or extracurricular programs (Berry et al., 2011; Martin, 2000; Stinson, 2008). Experiences and interactions with socializing agents are distinct and vary across relationships; however, the cumulative impact of these experiences appears to be significant in the stories individuals construct and internalize about their ability to learn and do mathematics.

Navigating Multiple Aspects of Identity

Earlier research revealed that students negotiate multiple identities (racial, gender, social, and mathematics) that conflict at times and require reconciliation (Fordham & Ogbu, 1986; Martin, 2000; Martin, 2006; Nasir & Saxe, 2003; Ogbu, 2002). While the question of navigating multiple aspects of identity initially stumped the participants, many of them were, ultimately, able to offer reflections on how their mathematics identities aligned with other perceptions of themselves and how they negotiated any contradictions. Ariel did not recall experiencing contradictions. Her self-perceptions related to mathematics aligned with her overall student identity where she viewed herself and was seen (and accepted) by others as a smart person and high achiever. Because of the diversity and inclusiveness in her school and classes, India also did not feel she was ever needed to reconcile her mathematics identity with other beliefs about herself. Unfortunately, this was not everyone's experience.

Thomas recalled the conflict between being a "smart kid" and fitting in with a certain peer group; however, he shared that his mother's expectations for his academic performance (and her consequences for failing to meet them) superseded his desire to fit in. Damian also spoke about

the reality of being an African American male adolescent and not wanting to be considered a "nerd". He described how, early in middle school, he did not consistently give his best effort and sometimes adopted the role of class clown in order to be "cool". Encountering his pre-algebra teacher in 8th grade, and wanting to meet the high expectations she held for her students, led him to decide that his academic performance was more important than trying to fit in. He found that his status among his peers was not negatively impacted by his decision to develop his mathematics and overall academic identity. Sable shared that, in her experience, being the "smart kid" was not very popular. While she did not reduce her effort or perform poorly to avoid teasing or comments from her peers, at times she downplayed her abilities and achievement to avoid attracting attention. Keisha and Natalie described navigating their academic and racial identities as shifting between different groups or as Natalie called it, "playing in both spaces." Keisha did not recall feeling conflicted during adolescence but, in retrospect, she realized that she had two different peer groups that allowed her to develop different aspects of her identity without contradiction. Natalie attributed our friendship (i.e., going through the experiences with a like-minded African American female) as a factor that helped her stay resilient as she navigated two "spaces".

Natalie had the strongest memories of navigating contradictions which I found interesting given our shared backgrounds. My adolescent experiences of navigating two, at times contradictory, worlds left an impression that eventually led to this line of research. She and I never talked openly about those challenges while we were going through them nor did we ever reflect on them as adults prior to her interview for this study. Hearing her perceptions of the same experiences validated that I was not imagining things at the time and had not blown them out of proportion over the years. Research that explores the burden of "acting white" such as Fordham & Ogbu (1986) or other forms of ostracization experienced by successful African American students

is controversial, particularly within critical race theory. However, there are African American students who must navigate the tension of pursuing success in mathematics, or academics in general and developing their racial identities and fitting in with same-race peers. For Thomas, Sable, Natalie, and Damian these tensions were experienced in environments where African American students were underrepresented. Previous research by Martin (2000); however, showed that academically successful African American students in predominately African American schools can face the same challenges. We cannot ignore these realities of African American students' experience. An acknowledgement and focus on how African American adolescents navigate these challenges does not minimize the overarching institutional and societal barriers that impact African American learners' academic performance and gateways to prosperity. One obstacle does not have to be sacrificed to tackle the other.

The common thread for participants in this study who faced the challenge of reconciling contradictions among different aspects of their identities was the influence one or more socializing agents. Parents or teachers helped them stay focused on the importance of gaining mathematical knowledge by holding them to high expectations. Like-minded peers (i.e., affinity groups, Gee (2000)) navigated the contradictions alongside them and provided a safe space to develop multiple aspects of their identities. The successful adolescents highlighted in Martin (2000) navigated challenges similar to the study participants, reconciling a positive mathematics identity with their African American identity or identity as a member of a certain peer group. Like the participants in this study, the students in Martin (2000) aligned themselves with like-minded peers and supportive teachers or family members to avoid sacrificing achievement for acceptance.

Foundational Mathematical Knowledge

The consensus among this small group of individuals was that Algebra 1 is the minimum mathematics course all high graduates should complete to be prepared for advanced mathematics coursework or STEM-related trades. This finding was not surprising as Algebra 1 is generally identified as the gateway course to a rigorous sequence of mathematics coursework (Domina, 2014; Moses & Cobb, 2001). Participants highlighted "basic" math, Algebra 1, and problem-solving skills as foundational mathematical knowledge. They also (unknowingly) referenced some of the concepts found in the definition of mathematics literacy for this study, namely proportional reasoning, statistics, solving equations, and relationships of geometric objects. It was interesting to note how frequently the phrase "basic math" was used by participants with the expectation that everyone knows and agrees on what math skills the phrase entails. Given the contexts in which the phrase was used by participants, I interpreted it to mean arithmetic or computation using one of the four operations (addition, subtraction, multiplication, or division); therefore, I considered "basic math" to fall under the umbrella of flexible computation skills which was also included in this study's definition of mathematics literacy. While the participants' terminology sometimes differed from the vocabulary used by mathematicians, the concepts and dispositions they identified as foundational also aligned with the National Research Council's (2002) essential strands for math proficiency—1) comprehension of mathematical concepts, 2) computational fluency, 3) application of mathematical concepts to solving problems, 4) logical reasoning, and 5) engagement (i.e., viewing mathematical knowledge as sensible, useful, and doable). Participants unwittingly touched on these strands of math proficiency all throughout their stories as they reflected on their engagement with mathematics during adolescence and shared what they enjoyed about the subject.

The Figured World of Mathematics

While planning this project, I wavered on whether a research question related to specific mathematics content and skills (RQ 4) fit within the overarching goals of this inquiry. It proved to be a question worthy of conclusion; however, because the participants' reflections on content and skills offered greater insight into aspects of their mathematics identities. An additional, unexpected, outcome of their musings was the light shed on their perceptions of the figured world of mathematics and their place within it. Holland and colleagues (1998) described figured worlds as social and cultural realms shaped by the collective activities, discourses, and performances of the characters/agents within them. Encounters within a world relegate actors to positions with more or less influence, privilege, or power and contribute to individuals' self-understanding (Holland et al., 1998). The roles learned in figured worlds are not deterministic, however, as individuals have agency over their own behavior and, by extension, their status within a figured world. Math is a figured world that students are required to enter, for a time, during middle and high school. Generally, past Algebra 1 or Geometry, individuals who feel alienated, ineffective, or powerless can elect to remove or distance themselves from this world.

The participants viewed mathematics as a world that was accessible to them and in which they belonged. Natalie and Damian spoke about how they viewed math as concrete, black-and-white, and logical. Eric characterized math as patterns and problem solving with numbers being used to explain the concepts. Ariel, Natalie, Sable, and Brianna's revealed that when learning math got tough, they did not view it as a roadblock or something to fear. Their beliefs can be summed up by Natalie's statement, I knew I could figure things out when it got tough." Keisha and Brianna shared examples of how they exercised agency after receiving a poor grade in a math class and rewrote the stories about their ability to do mathematics. Eric described how he and peers from his

home school worked hard, achieved success, and changed the way they were perceived by staff and students at his middle school. Eric also recalled the moment when he realized the level of influence he could have within the world of mathematics, "I'm good at this. I can teach it to others". The participants' stories offer evidence that individuals with positive mathematics identities recognize their ability to have influence and exercise agency in the figured world of mathematics and are more likely to continue engagement within this world after it is no longer formally required.

Implications

This project was inspired by a desire to examine how experiences in adolescence support positive identification with mathematics, particularly for African American youth. Mathematical knowledge is foundational for the advanced mathematics and science coursework needed to purse STEM-related occupations after high school. I argue that being able to see oneself as a person capable of learning and doing mathematics, in middle and high school, impacts African American learners' engagement, motivation, and persistence to gain mathematical knowledge. There is a need for more research that considers the perspectives of African Americans who demonstrated long-term persistence with mathematics and leveraged their mathematical knowledge to pursue a variety of opportunities after completing their K-12 education. This study sought to add to that literature. Understanding how secondary experiences and interactions facilitated the development of positive mathematics identities for successful adults can offer insight into practices and opportunities that might support today's African American youth in developing positive dispositions towards mathematics.

Participants' stories of their current self-perceptions and engagement with mathematics revealed that the positive mathematics identities they developed during adolescent continued into

adulthood. This finding offered a complement to Martin (2006, 2007) who demonstrated the other side of the same coin— individuals who developed negative dispositions towards mathematics in middle and high school sustained those perceptions well into adulthood. The findings related to participants' sustained positive mathematics identities, along with their persistence into STEM-related careers, also offered support for prior research that showed a positive association between middle school mathematics and science interest in the middle grades and pursuit of a STEM career (Dabney et al., 2012; Maltese, Melki, & Wiebke, 2014; Tai, Liu, Maltese, & Fan, 2006). Like earlier studies examining individuals with positive mathematics identities (e.g., Berry, 2005, 2008; Berry et al., 2011; Borum & Walker, 2011; Martin, 2000; McGee & Pearman, 2014, 2015; Stinson, 2008), this study demonstrates that there is no formula or recipe for fostering a positive mathematics identity in learners. Even within this small group of participants, no two people had the same story. Furthermore, there are many "successful" adults (African American or other) who had otherwise positive academic experiences, but do not consider themselves to be "math people" (Boaler, 2016). Something about those individuals' adolescent experiences caused them to internalize a belief that they were not good at learning and doing mathematics.

While there may not be a recipe for fostering positive mathematics identities, there appear to be some common "ingredients" contributing to their development. A common thread across the participants' stories was the presence of multiple factors—some internal, others external—that cumulatively had a positive impact on their mathematics identities. Internal factors contributing to participants' adolescent mathematics identities included career interest, beliefs about the opportunities mathematical knowledge could provide, enjoyment of the challenges that came with learning mathematics, or determination to overcome setbacks such as poor performance in math. External factors contributing to participants' developing mathematics identities included

participation in formal or informal communities of practice that encouraged the application of mathematical knowledge, recognition by others as a "math" person, and interactions with socializing agents such as parents, teachers, and peers. Socializing agents' influences included providing support with learning mathematics, sharing direct or indirect messages about the importance of mathematical knowledge, holding high expectations for participants' performance in mathematics, or serving as role models for participants look up to or emulate. Additionally, some of the participants recognized they were viewed as role models for others and felt a responsibility to not disappoint. Socializing agents also appeared to help participants navigate contradictions that arose between their positive mathematics identity and other aspects of their identity such as their developing racial identities. For example, several of the participants found that relationships with like-minded peers of the same race (i.e., affinity groups (Gee, 2000)) provided a space for them to develop both their mathematics and racial identities.

The number and combinations of supporting factors varied across participants; however, each of them referenced at least three (up to eight) of the eleven supportive factors identified in the data collected from this small group of individuals. When participants encountered obstacles with the potential to negatively impact their developing mathematics identities and rewrite their stories (e.g., marginalization, poor performance), the foundation of positive past experiences and the support of socializing agents appeared to serve as protective factors fueling a belief they could overcome the challenges and continue to learn and do mathematics. This finding about the resilience of participants' mathematics identities offers support for the second assumption underlying this research; learners' self-perceptions related to mathematics impact their participation in the practices that support their learning, willingness to risk mistakes, and motivation to persist when learning becomes difficult. Within this small group of individuals,

females and males did not report differential experiences of learning and doing mathematics. While some of them reported instances where race appeared to be a factor impacting their experience, none reported feeling that gender was an issue.

Participants identified the content learned in Algebra 1, problem solving, and "basic" math (i.e., computational fluency) as the foundational mathematical knowledge that prepared them for the coursework needed to purse their careers. This finding adds support to the fourth assumption underlying this study—the mathematical knowledge learned through the end of middle school (pre-algebra or Algebra 1) is foundational for secondary mathematics and science coursework. This finding also aligns with the consensus that Algebra 1 is the gateway course to a rigorous sequence of mathematics coursework (Domina, 2014; Moses & Cobb, 2001). The participants' stories, along with their reflections on foundational math content and skills, suggest that individuals with positive mathematic identities recognize their ability to have influence and exercise agency in the figured world of mathematics and are more likely to continue engagement within this world even when it is no longer formally required.

Recommendations

Applications

The findings from a small qualitative study are not generalizable; however, when considered along with previous research, there are three possible applications to practice. First, there is a need to continue developing school-based and out-of-school programs aimed at exposing African American adolescents to STEM and helping them to see how what they are learning in the mathematics classrooms is applied in the real world. Many of the study participants described opportunities to engage with mathematics in multiple communities of practice. The development

and application of their mathematical knowledge beyond the classroom helped foster their positive dispositions towards mathematics.

A second recommendation is to increase efforts to educate African American parents about the variety of occupations related to STEM and the foundational math knowledge needed to gain access to these occupations. This sample of participants appeared to be fairly homogenous with regards to access to information about STEM. Their stories suggested they came from middle class families with parents who, not only recognized the importance of education and the opportunities it could provide, but also had the social capital to ensure their children were not denied access to opportunities. Many of the participants spoke about their parents' high expectations for their school performance, messages about the importance of mathematical knowledge, advocacy on their behalf, or a combination of the three. Several of the participants mentioned having at least one parent with a college education. Three participants had parents with mathematics degrees and one had a parent with a Ph.D. in Engineering. The homogeneity of this small group could serve as evidence that African American learners without similar resources or supports, regardless of their disposition toward mathematics, are even less likely to be represented in STEM-related careers than their more privileged peers. Greater efforts need to be made so that parents from *all* backgrounds are aware of the gateways mathematical knowledge opens. Additionally, parents need to know that the need for mathematical knowledge is not limited individuals interested in pursuing STEM majors in college so they can support schools in communicating that message to their children. It is important to note that providing information to families from all backgrounds will not be enough to increase access to opportunity. There are institutional structures in this country that impose barriers to certain groups and facilitate inequality; however, an examination of these structures was beyond the scope of this project. This small project addressed how individuals from

a historically marginalized group navigated within the realities of this unequal system. However, that focus is not meant to minimize the need for changes in discriminatory structures and practices.

Finally, schools of education and school districts need to continue efforts to recruit African American secondary teacher for STEM-related courses. Within this small sample, eight out of ten participants encountered at least one African American mathematics teacher. Calvin and Keisha were the only two participants who did not encounter at least one African American math teacher in middle or high school. Keisha did, however, speak about African American female science teachers from middle school who she admired and looked to as role models. Damian, India, Thomas, and Ariel all noted that the mathematics teachers who stood out the most in their minds after all these years were African American teachers. Damian recalled his pre-algebra teacher holding her African American students to very high expectations. India shared a story of her math teachers who worked with her outside of class time and helped her show her work and communicate her thinking rather than penalizing her. Thomas remembered his teachers communicating messages and offering examples of the importance of mathematical knowledge. Ariel talked about her geometry teacher who facilitated an after-school activity aimed at exposing African American students to engineering. This finding about the impact of African American teachers on participants' experiences, taken with other studies that have shown having a same race teacher to be positively associated with outcomes for African American students (Egalite & Kisida, 2018) suggests that teacher representation in the classroom could serve as a factor that bolsters African American learners' mathematics identity development.

Future Research

My first suggestion for future research would be a comparison study of "successful" adults that includes individuals who continued to engaged with mathematics into adulthood and those

who express an aversion to mathematics and declare they are not 'math people'. Through a comparison of their stories, it might be possible to identify notable differences in their adolescent experiences with mathematics and begin highlighting factors that hinder the development of a positive mathematics identity. Next, additional research is needed that examines African Americans representation in advanced math classrooms and students' perception of their environment. This small study revealed instances of marginalization that occurred in advanced mathematics classes where African Americans were underrepresented. However, this experience was not consistent across participants. Some indicated they never felt marginalized even though they were always one of few African American students in their classes. More research is needed to determine the degree to which African American students feel fully included or marginalized in these environments. Finally, the mathematics teacher in me was intrigued by participants' use of the terms 'basic' and 'new' math. What do laypersons mean by these vague, but commonly used, terms? What math skills and content are (or should be) considered "basic"? Is 'basic' math limited to prerequisite knowledge for Algebra 1 or should the skills and content learned in the gateway course, Algebra 1, be considered part of the 'basics'? When participants spoke of 'new' math, they indicated they didn't know what it was (India, Calvin) or that they felt less comfortable with it than the math they learned in school (Thomas, Natalie). Given that parents are important partners in shaping learners' dispositions towards mathematics, research is needed to examine adults' perceptions about 'new' math and how those perceptions might impact the messages they communicate to their children about mathematics. Additionally, researchers and math educators need to produce accessible information for laypersons that clarifies that 'new' math is not actually new math and that the difference is in the way it is taught (i.e., conceptually rather than rote memorization of steps).

Limitations

"At the end of the day people won't remember what you said or did; they will remember how you made them feel" – Maya Angelou

The retrospective nature of this study restricted the data to self-reports. It was not possible to observe participants engaging with mathematics in a learning environment or to review artifacts such as classwork, math journals, or middle or high school transcripts. Nor was it possible to speak with other individuals who co-constructed experiences with the participants (i.e., their socializing agents) and could provide additional perspectives or corroborate their stories. While there are limitations to retrospective self-reports, they can offer valuable insight into the experiences that influenced individuals' self-perceptions. Martin (2006) expressed surprise at the vividness of participants' memories of their secondary mathematics experiences. Boaler (2016) also noted that many adults have distinct memories of experiences that led to them to have strong feelings about mathematics. This study aimed to examine factors that influenced participants' perceptions of themselves as learners and doers of mathematics; therefore, the emphasis was put on the *what, who,* and *how* of experiences (e.g., *What did you experience? With whom did the interaction take place? How did the experience make you feel?*), rather than specific details such as precisely *when* and *where* defining moments may have occurred.

An example of the challenge of drawing conclusions from individuals' perception of past experiences is Thomas' story about the Caucasian teacher in whose class he felt marginalized. It is possible that the teacher did judge Thomas from the outset and treated him as though he did not belong in her class. However, Thomas admitted to being unreceptive and disruptive in her classroom. Which happened first, her making him feel unwelcome or his acting out and her making assumptions about his ability as a result? Were there other factors or incidents that created or

reinforced a negative dynamic in which neither student nor teacher was willing to give each other a chance? What were the experiences of other African American students in this teacher's class? These questions simply cannot be answered two decades later. However, like the Maya Angelou quote above, I argue that the "facts" of Thomas' experience are less important than how it made him feel and how those feelings stuck out in his memory all these years later. Thomas transferred to a new teacher, continued to be successful in mathematics, and was able to pursue a high demand STEM-related career. There are African American adults with similar past experiences with high school teachers who reacted by disengaging from mathematics, shutting the door to potential opportunities (Martin 2006, 2007).

Insights from this study were also limited by the lens chosen for this inquiry. Such a limitation is unavoidable if one is to design a manageable project. For example, for the sake of parsimony, I chose not to address the ways in which social class and race intersect in our society. While African American mathematics learners might face structural impediments such as limited access to advanced mathematics coursework, it is also true that they might not have the same academic supports or advocates outside of school as their peers. A lack of support is more likely related to social class than skin color; however, in the United States, social class and race are rarely entirely independent of one another (Lareau, 2011). This small sample of participants was relatively homogeneous in terms of social class (i.e., their stories suggested middle class backgrounds); therefore, socioeconomic status did not emerge as salient in the findings. In a larger sample with individuals from more diverse backgrounds, social class may have appeared as a factor impacting participants' experiences and access to certain opportunities. Another example of the limits imposed by the lens chosen for this inquiry, is the decision to not foreground the project in critical race theory. A project firmly grounded in this perspective would have given more

attention to the structural barriers African Americans face in school and society. This project limited the larger social context in which the participants' experiences took place and zoomed in positive experiences and supports while giving less attention to barriers or negative experiences. Examples of obstacles did emerge from participants' stories; however, they were not the primary focus of this inquiry.

There were additional limitations related to the logistics of the project, the first being the small sample size. A sample size of ten is not large enough for generalizability. Another challenge of starting with a small sample size was that after attrition, there were only enough participants remaining to conduct one focus group. I was fortunate that the group ended up offering the perspectives of both genders (2 females and 2 males); however, it was difficult to make claims about collective themes from a group of four people. A third limitation was the inability to recruit individuals from trades for participation. One of the goals of this study was to challenge the idea of what occupations are considered "successful" (i.e., white collar vs. blue collar) and include STEM-related careers that do not require a college education. Additionally, I wanted to give voice to African Americans who elected not to pursue postsecondary education but still ended up in high demand occupations.

While these next points may not qualify as study limitations, there are methodological changes I would make when reproducing this research in the future. The first change would be a larger sample size. In a future study, I would recruit two to three times more participants. Increasing the sample size could allow for more representation of a wider variety of STEM-related careers, increase the diversity in participants' backgrounds, and increase the chances of recruiting individuals from trades. A larger sample would also allow for more focus group discussions and offer more evidence from which to draw conclusions about collective experiences. One small

adjustment I would make to the interview process would be to provide a copy of the interview questions to the participants. Some of the questions were wordy, thought-provoking, or downright confusing and participants frequently asked for questions to be repeated.

After the first two or three interviews, I started to wonder if it would have been helpful for participants to receive the interview questions ahead of time to give them an opportunity to think about their responses and possibly do some "research" in the form of checking their high school transcripts or report cards, pulling out old yearbooks, or even talking to friends and family members. I did not think it would be appropriate to make this change midway into data collection; however, I would take this approach in a future study. Finally, I would make a few additions to the Participant Information and Math History Form. I would add a section for participants to rate their current comfort level with mathematics and explain the rating. I would also add a question about the highest-level math they think all students should complete in high school and provide a checklist of foundational math skills that they could circle, check, or rank. I was fortunate to be able to collect all this information during the study; however, a more systematic method for collecting the information would be easier to analyze and offer more consistency in soliciting this information from each participant.

Conclusion

This study contributed to the literature considering the perspectives of African Americans who successfully leveraged mathematical knowledge in pursuit of various opportunities after completing their K-12 education. Studies of successful individuals from underrepresented groups can—in addition to suggesting possible guides for practice—illuminate potential challenges facing many members of the group and provide insight into individuals' agency and resilience in the face

of those challenges. This study's findings demonstrated that a combination of internal and external factors contributed to the development of participants' adolescent mathematics identities. It also confirmed that positive mathematics identities developed in adolescence last into adulthood. There are many factors beyond the scope of this project that impact African Americans' access and persistence into STEM-related careers. However, taken into consideration with prior research, this study's findings offer evidence that increasing opportunities for participation in school-based and out-of-school STEM programs, increasing efforts to educate African American parents about the diversity of STEM-related careers and mathematical knowledge needed for entry, and continuing efforts to increase the representation of African American teachers in STEM-related courses are among the practices educators can take to support African American learners' perceptions of mathematics as a gateway to a successful future.

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Appendix A

PARTICIPANT RECRUITMENT FLYER

Spring 2018 Research Study

Teri Johnson, a doctoral student in the School of Education at Virginia Commonwealth University (VCU) is currently recruiting participants for a dissertation research study.

Study Title
Mathematics Identity Construction in Successful African Americans: Reflections on Mathematics Experiences During Adolescence

Purpose of the Study
To learn about experiences during the middle and high school years that contributed to the development of positive mathematics identities in successful African Americans.

Who is eligible to participate in this study?

- African American men and women (ages 21 – 40) who have worked in a STEM-related occupation for 3 or more years
    - Examples of STEM-related occupations: accounting, education, engineering, healthcare (nursing, medicine, pharmacy, dentistry), information technology (IT), pharmacy, trades (carpentry, plumbing, electrical)
- Participation is not limited to the occupation listed above. If you enjoy mathematics and work in job that requires math skills or knowledge, I would love to hear your story!

What is required if I decide to participate?

- Completion of a brief Participant Information and Math History Form
- One 45-60 minute individual interview
- One 90 – 120 minute focus group interview with other study participants

Will I be compensated for my participation?

- In addition to the opportunity to connect and share your experiences with individuals from similar backgrounds, participants will receive a free lunch or dinner during the focus group interview.

Are you interested in sharing your story?
OR
Do you know someone who would be a good fit for the study?

For more information, contact
Teri Johnson
Phone: (804) 304 – 2680
Email: mortontn@vcu.edu

Appendix B

RESEARCH PARTICIPANT INFORMATION SHEET

STUDY TITLE: Mathematics Identity Construction in Successful African Americans: Reflections on Mathematics Experiences During Adolescence

VCU INVESTIGATORS: Teri N. Johnson, M.Ed., Doctoral Researcher and Dr. Kurt Stemhagen, Associate Professor, Foundations of Education, VCU Principal Investigator

You are being invited to participate in a research study about the middle and high school experiences that contributed to the development of positive mathematics identities in successful African American men and women. This study is being conducted as dissertation research. Your participation is voluntary.

In this study, you will be asked to do the following things:

1. Complete a Participant Information and Math History Form;
2. Participate in one 45-60 minute individual interview (in-person or by phone); and
3. Participate in one 90-120 minute focus group interview (in-person or online) with approximately 3-5 other participants from the study.

Your participation in this study will last up to a total of 195 minutes (just over 3 hours) over 2-4 weeks.
If you have any questions, concerns, or complaints about this study now or in the future, please contact-

Teri N. Johnson; 804-304-2680; mortontn@vcu.edu
or
Dr. Kurt Stemhagen; 804-827-8415; krstemhagen@vcu.edu

Appendix C

PARTICIPANT INFORMATION AND MATH HISTORY FORM

The information provided in this form will serve two purposes:

1. *To provide the researcher with background information in preparation for the interview;*
2. *To stimulate your recall of middle and high school math experiences.*

Name: _____ Age: _____ Gender:_____

Occupation: _____ Years in occupation: _____

Education: *Check or highlight all that apply*

- High school diploma/GED Year of Graduation:
- Bachelor's degree Major:
- Master's degree Major:
- Doctoral degree Major:
- Professional certifications:

Middle School Information

City, State: _____

Circle or highlight the descriptors that apply.

- Urban Suburban Rural
- Public Private
- Charter school Magnet school Specialty Center

Were math classes grouped by ability (tracking)? YES NO

High School Information

City, State: _____

Circle or highlight the descriptors that apply.

- Urban Suburban Rural
- Public Private
- Charter school Magnet school Specialty Center

Were math classes grouped by ability (tracking)? YES NO

Math Course Sequence: *Circle or highlight the sequence that applies to you.*

Grade	Traditional Sequence	Accelerated Sequence	If neither apply, type or write your HS course sequence below
8th	Pre-Algebra	Algebra 1	Other:
9th	Algebra 1	Geometry	Other:
10th	Geometry	Algebra 2/ Trigonometry	Other:
11th	Algebra 2/ Trigonometry	Math Analysis/ Pre-calculus	Other:
12th	Math Analysis/ Pre-calculus	Calculus	Other:

African American female middle/high school mathematics teachers: _____

African American male middle/high school mathematics teachers:_____

Extracurricular activities related to mathematics *(Check or highlight all that apply.)*

- Afterschool tutoring
- Afterschool club
- Math or STEM competitions (e.g., 24 game, robotics, engineering)
- Summer camp or summer enrichment program
- Other: _____

Return completed form by email to Teri Johnson, mortontn@vcu.edu.
Thank you for your participation!

Appendix D

INDIVIDUAL INTERVIEW PROTOCOL

"Thank you for participating in this interview today. The purpose of this tudy is to learn about the adolescent experiences of successful African American men and women that contributed to their self-perceptions as learners and doers of mathematics. My hope is that findings from this project along with other studies of mathematics learning and achievement among African Americans will help inform the development of math supports and interventions for African American youth today and in the future.

As a reminder, this interview is being digitally recorded. I will also take notes during our discussion. Please remember that you may decline to answer any question and you may stop the interview at any time. Do you have any questions for me before we begin?"

1. Tell me about your occupation.
    a. What training did you receive to prepare for your career?
    b. Describe a typical day at work.
        i. Can you give examples of the types of problems you might have to solve?
    c. How well represented are African Americans in your occupation?
2. Tell me about the middle and high schools you attended.
3. Did your schools place students on different academic tracks? Did the advanced math classes mirror the composition of the student body?
4. How would you describe yourself as a student in middle/high school?
    a. What classes did you enjoy the most?
    b. What activities did you enjoy outside of school?
5. Were your closest friends in your math classes?
    a. If not, how did that make you feel?
    b. How did it affect how you saw yourself as a math student?
6. At this point in your life, how do you feel about math?

a. On a scale of 1-10, with 10 being the highest, how would you rate your comfort level with mathematics? On what factors would you base your rating?

7. Can you share one or more affirming experiences with mathematics in middle/high school? These experiences could have occurred inside or outside of school.
8. How did other aspects of your identity (e.g., race, gender, or peer group) intersect with your developing mathematics identity during adolescence?
9. Did you ever feel that there were low expectations for your math performance?
    a. If yes, what or who was the source of the low expectations? What made you aware of those expectations?
    b. Did those expectations affect your effort/motivation? If yes, how so? If no, what factors encouraged you to persist?
10. Tell me about messages you received about the importance of mathematics from the important people in your life.
    a. What messages did you receive from your parents? Teachers? Peers? Other influential individuals?
11. Where could you turn when you had difficulty with math content in middle/high school? What type of support did you receive?
12. Do any of your middle/high school math teachers stand out in your memory? What made them more memorable than the others?
13. Describe any extracurricular activities or experiences that gave you exposure to mathematics outside of the classroom.
    a. How did those experiences contribute to your feelings about mathematics?
14. What, if any, impact did your feelings about math have on your math and science course

selection in high school?

15. What led you to your current career?
16. What are some of the math courses or topics you studied in middle/high school that provided you with a strong foundation for your career?
17. African Americans continue to be underrepresented in STEM-related occupations. What kept math from becoming a gatekeeper (obstacle) for you? To what do you attribute your success in mathematics and persistence into your career?
18. Do you have any additional questions for me regarding the study?
    a. Is there anyone else you think would be interested in sharing their experiences with me?
    b. If yes, would you be willing to share a recruitment flyer with them?

"Thank you for your time and participation today."

Appendix E

FOCUS GROUP DISCUSSION GUIDE

"Thank you for your participation in this focus group interview today. The purpose of today's interview is twofold. First, hearing the stories of other individuals may trigger additional memories of your middle and high school experiences. Second, your collective stories may reveal common themes in the formative experiences of successful African Americans.

During this interview I (the researcher) will pose a series of questions for discussion. We will spend anywhere from 5 to 15 minutes on each question. In order to keep the discussion on track with respect to time, you will be asked to limit individual remarks to 2-3 minutes each. Some questions will spark more discussion than others. On an individual level, it is normal for some questions to evoke more contributions from you than others. After the final question has been discussed, each of you will be given an opportunity to share a closing thought.

As a reminder, this interview is being digitally recorded. To maximize the quality of the audio recording, it is important that only one person speaks at a time. In addition to the recording, you may observe me taking notes during the discussion. Please remember that you may decline to answer any question and you may stop the interview at any time. To protect everyone's confidentiality, I ask that whatever information is shared during today's discussion remain between the individuals in this room. Do you have any questions for me before we begin?

Before we get into the discussion questions, let's take a minute to introduce ourselves to the group. As we go around the room, please share your name, the city and state where you attended middle and high school, and your current occupation."

Discussion Questions

1. Discuss some of the individuals whose opinions were most valuable to you in middle/high school?
    a. What expectations did those individuals hold for you related to mathematics?
    b. Were those expectations shared directly or implied?
2. Discuss the demographics of your middle/high schools.
    a. Were math classes tracked by ability?
    b. Did the math classes mirror the composition of the student body?
3. Think about other identities you were negotiating during adolescence (e.g., race, gender, or

peer group). How did these identities intersect with your developing mathematics identity during your middle/high school years?

4. Did you ever encounter individuals who held low expectations for your math performance?
    a. Who were the sources of these expectations and how did you pick up on them?
    b. What impact did these messages have on your motivation to learn mathematics?
5. Discuss the type of experiences and interactions—inside the classroom or out—that motivated you to learn and persist with math.
    a. Share any experiences that gave you exposure to math outside of school.
6. Discuss the math teachers that stand out in your memories of middle/high school. What characteristics make those teachers stand out more than less memorable math teachers?
7. Discuss the math classes or topics you studied in middle/high school that provided you with the knowledge and skills you needed to pursue your careers.
8. African Americans continue to be underrepresented in STEM-related occupations. Discuss what kept math from becoming a gatekeeper (obstacle) for you.

"*We have completed the series of discussion questions. We will conclude this group interview session will a final word from each participant on their experiences with mathematics."*

(Participants will each be given 2-3 minutes to share a final thought on their experiences).

"Thank you for your participation today and all your contributions to this research study."

Appendix F

PARTICIPANT MATRIX

Name	Gender	Age	Occupation	Years in Occupation	HS Graduation	Education	MS/HS	Course Sequence	African American Teachers	Extracurricular
Sable	Female	40	Science: Lab Director	19 (3 as director)	1995	HS; BS-Biology; MS-Medical Technology; PhD-Public Health (Epidemiology); M(ASCP) Certification	Suburban, public, tracking, VA	Accelerated sequence	0 female, 1 male	Summer program
Brianna	Female	33	Education: Student Growth Specialist	12	2003	HS; BS_Mathematics; M.Ed. Curriculum & Instruction Math Specialist K-8; 21st Century Skills Certification	Rural, public, tracking, VA	Accelerated sequence	2 females, 1 male	
Natalie	Female	39	Techology: IT Project Manager	11 (3 as manager)	1996	HS; BS-Chemical Engineering; Business minor; MBA; Project Management Professional Certification	Suburban, public, tracking, VA	Accelerated sequence	1 female, 1 male	Summer program
Ariel	Female	40	Engineering: Director	18	1996	HS; BS-Chemical Engineering	Rural, public, tracking, NC	Alg 1, GEO, Alg 2, Alg 3, Pre-Calc	1 female, 1 male	Summer program
India	Female	40	Economist	17	1995	HS; BS-Political Science; MS-Economics	Rural, public, tracking, SC	Accelerated sequence w/o Calculus grade 12	0 female, 1 male (2 years)	Afterschool tutoring, STEM competition (Science Academic Challenge)
Keisha	Female	41	Science: Assistant Professor/Researcher	9+ (3 as Asst. Professor)	1995	HS; BS-Clinical Laboratory Sciences; PhD. Microbiology & Immunology; Medical Technologist certification (American Society for Clinical Pathology)	Suburban, public, tracking, VA	Traditional sequence	0 female, 0 male	
Bryce	Male	23	HS Math teacher	2	2013	HS; BS-Mathematics	Suburban, public, tracking, VA	Accelerated sequence	1 female, 0 male	afterschool club
Thomas	Male	38	Traffic/Electrical Engineer	10	1998	HS; BS-Electronic Engineering Technology	Suburban, public, tracking, VA	Traditional sequence	4 female, 4 male	"slanging"
Calvin	Male	39	Production Manager	17	1997	HS; BS-Chemical Engineering, minor in business	Suburban, public, tracking, VA	Traditional sequence	0 female, 0 male	
Damian	Male	39	Technology: Systems Engineer	19	1996	HS; Professional Certifications- IBM Certified System Administrator: IBM Webspace Portal, Lotus ND 51616.517.1; IBM Certified Professional: Lotus Team Workplace	Suburban, public, tracking, VA	Traditional sequence	1 female, 0 male	

Appendix G

PROVISIONAL CODING SCHEME

Code	Subcodes
Socializing Agents	Parents
	Teachers
	Role models (extended family)
	Role models (community members)
	Peers
Communities of Practice	School
	Math classroom
	Extracurricular activities/programs
	Neighborhood
Mathematics Identity	Ability to perform
	Opportunities & constraints
	Importance of math knowledge
	Motivation & Persistence

Vita

Teri Nicole Johnson was born on May 5, 1978, in Chesterfield County, Virginia and is an American citizen. She graduated from Meadowbrook High School, Chesterfield County, Virginia in 1996. She received her Bachelor of Science in Psychology from Virginia Commonwealth University in Richmond, Virginia in 1999 and subsequently taught middle school mathematics and science in public schools in Virginia and North Carolina. She received a Master of Education in Administration and Supervision from the University of Virginia in 2006. She currently works as a Coordinator of Assessment and Remediation in Chesterfield County Public Schools.